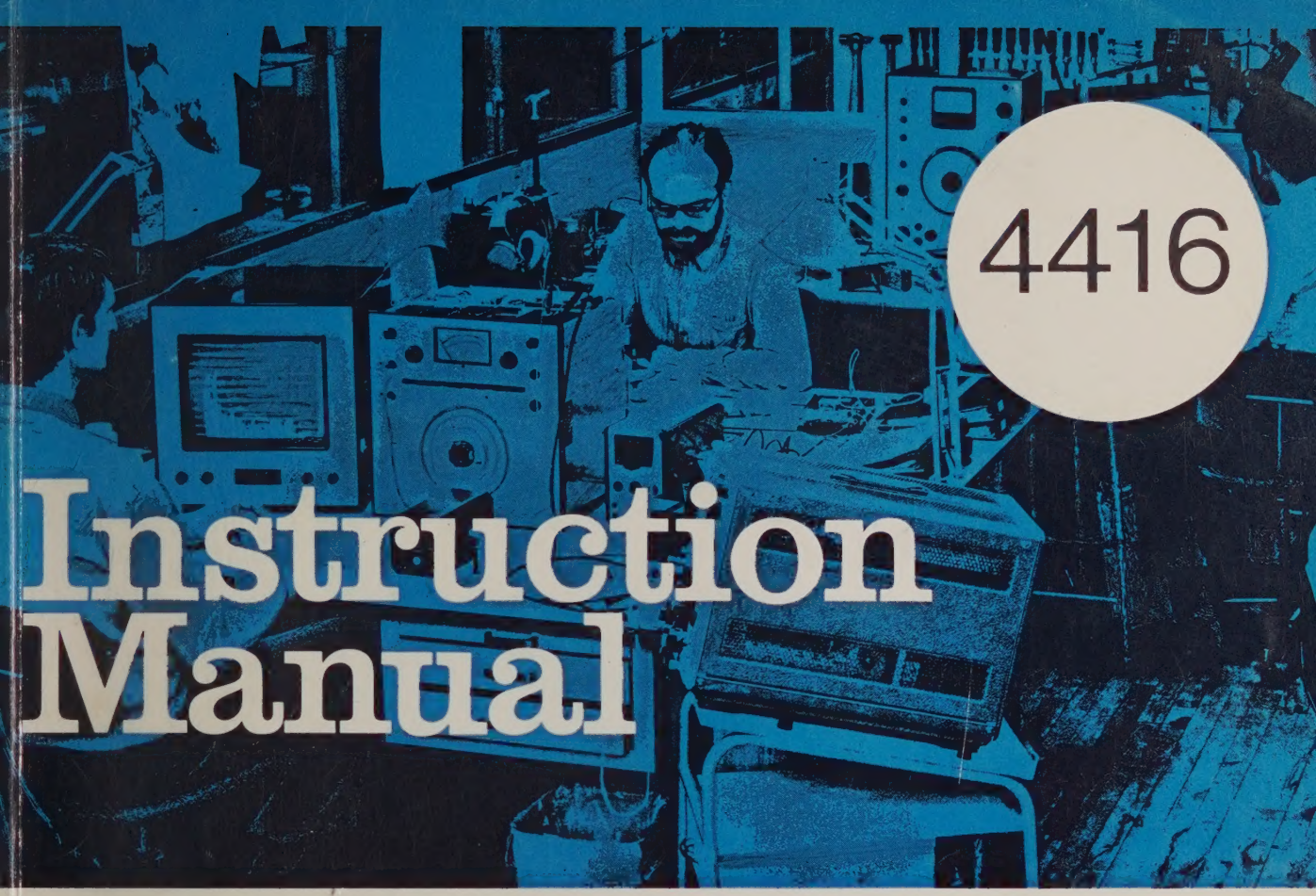


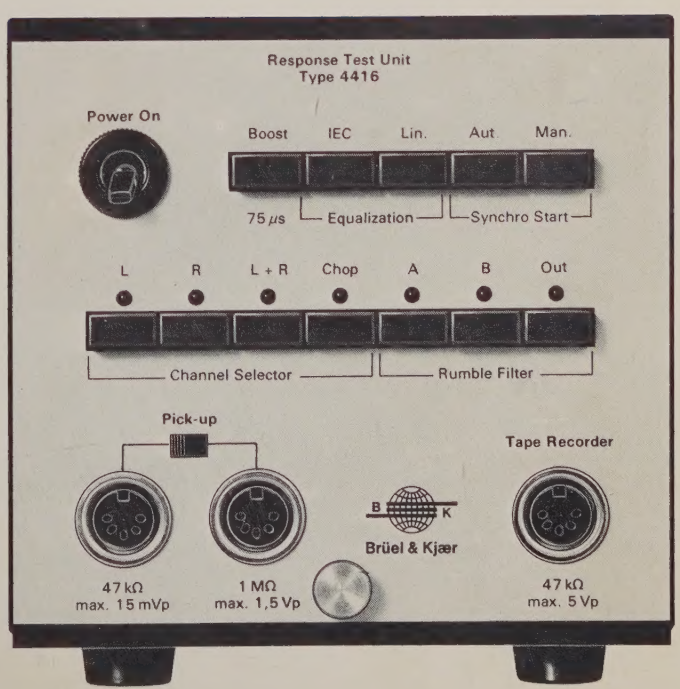
4416

Instruction Manual

Response Test Unit Type 4416 and Test Records QR 2009, QR 2010, and QR 2011

The Response Test Unit Type 4416 facilitates fast accurate testing of audio reproduction systems. Many of the important parameters such as frequency response and cross-talk may be measured automatically, with the correct equalization and synchronization being provided by the 4416.

Test Records QR 2009, QR 2010, and QR 2011 contain reference programmes specifically designed to test Hi-Fi record-playing equipment, with the 4416 forming the link between the records and the rest of the measuring system. QR 2011 may be used without the 4416 for testing complete systems, simply by measuring with a Sound Level Meter.



Brüel & Kjær

033-0183

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RESPONSE TEST UNIT
TYPE 4416
AND
TEST RECORDS
QR 2009, QR 2010 & QR 2011

June 1976

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type 4416, QR 2009, QR 2010 and QR 2011

Response Test Unit, Test Records

FEATURES:

- Automatic synchronization with B & K equipment
- Possibility of printed documentation
- Fast operation time
- Compliance with IEC R98, DIN 45547, BS 1928: 1961 and RIAA
- Built-in channel selector
- Built-in equalizing filters
- Built-in rumble filters

USES:

- Production control of, and laboratory investigations on, gramophone pick-ups, record players, tape recorders, dictation machines, motion picture sound systems and complete audio reproduction systems
- Crosstalk measurements on stereo systems
- Fast frequency response measurements on audio equipment
- Phase check of complete Hi-Fi systems by simple listening method
- Response test of complete Hi-Fi systems installed in the actual listening room
- Recording of test tapes

The Response Test Unit Type 4416 forms the link between the reference programmes recorded on the Test Records QR 2009, QR 2010 and QR 2011 or on tape recorders etc., and the extensive range of automatic audio system test instruments produced by Brüel & Kjær.

The main function of the instrument is to de-emphasise the output signal from pick-up cartridges, and to start a Level Recorder Type 2305 or 2307, so that synchronization is obtained between the frequency sweep on the test record and the frequency calibrated paper on the Level Recorder. In cases where the ability to record is built into the device under test, for instance, tape recorders, dictation machines etc., reference recordings can be made by means of a Sine Generator Type

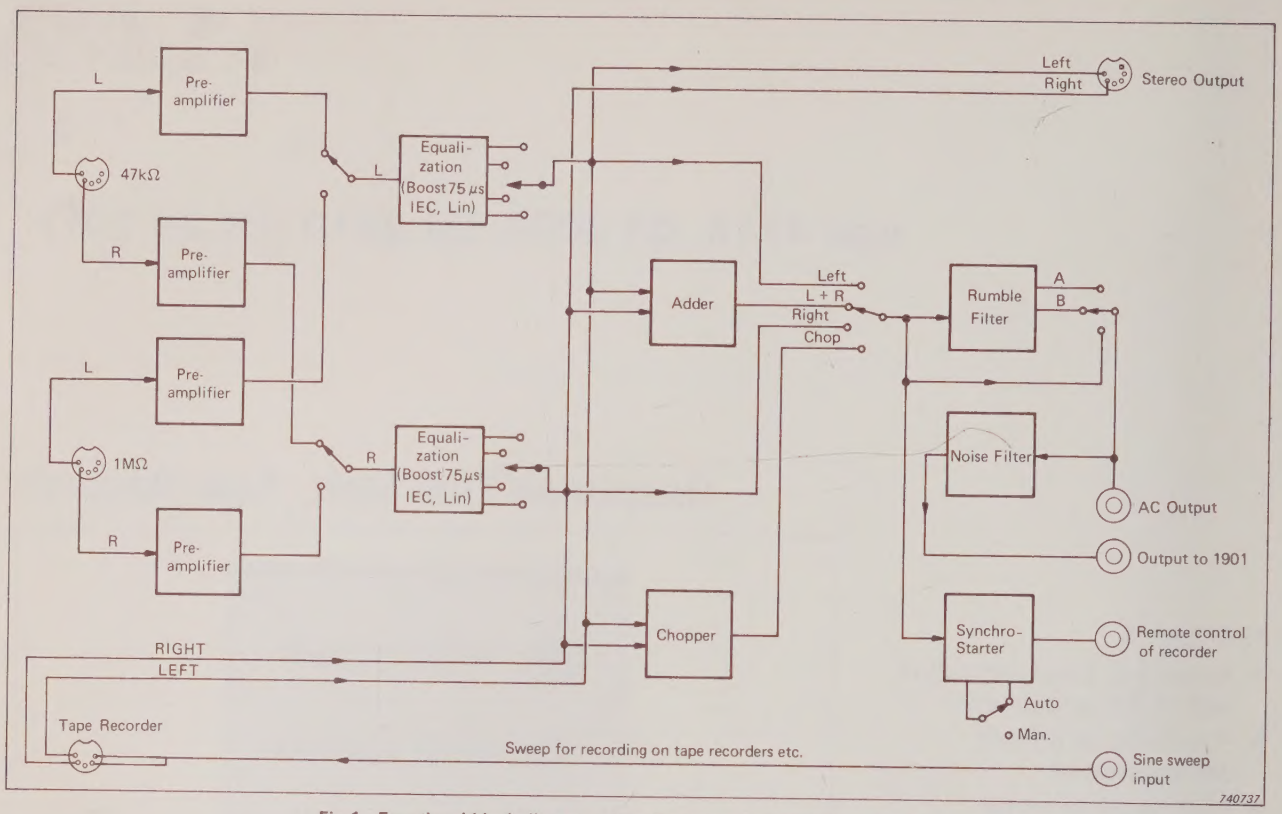

Fig.1. Functional block diagram of the Response Test Unit Type 4416

1023, automatically swept by the Level Recorder.

The Test Unit has a built-in electronic switch, which allows separation and balance measurements to be made on stereo systems, as well as both standardized rumble weighting filters, A and B (DIN 45539) for measurement of turntable rumble.

Response Test Unit Type 4416

The instrument has three inputs: one designed for measurements on dynamic pick-ups, one for measurements on piezoelectric pick-ups and one for the testing of tape recorders. From the two inputs for pick-up measurements, the stereo signals are fed through a pair of preamplifiers giving the signals suitable amplitude for further processing. After amplification, the signals are fed to the equalizing networks. Designed to apply the required de-emphasis to the signal in all normal situations, they should be used as follows:

1) Where a preamplifier with built-in equalization is built into the de-

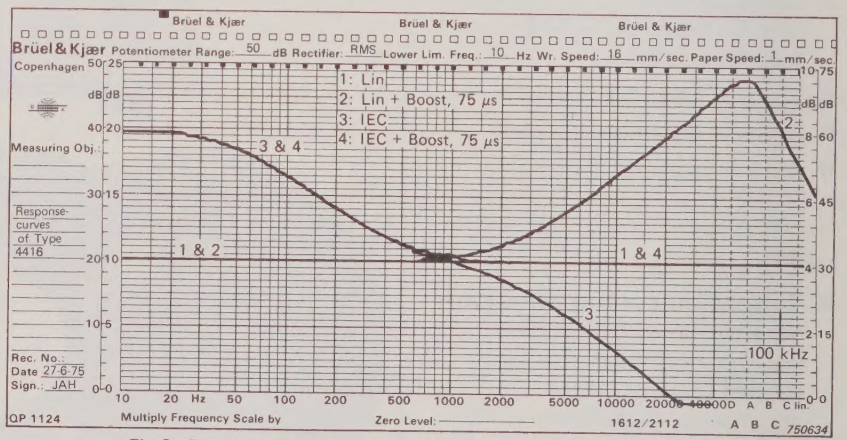

Fig.2. The four different deemphasis functions built into Type 4416

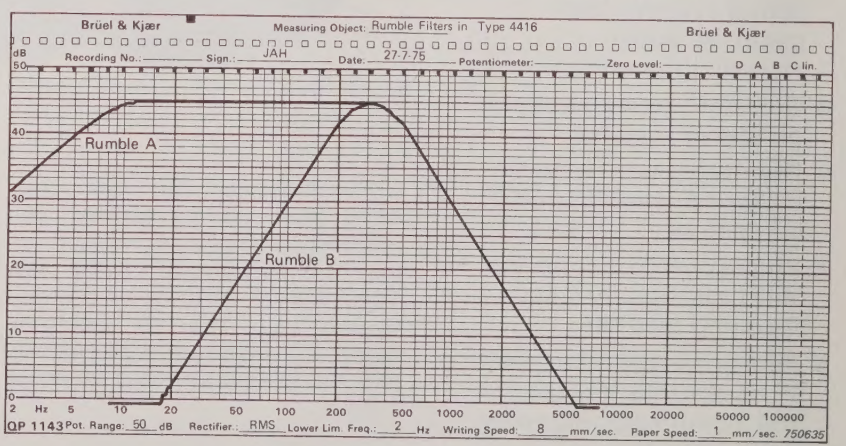
Brüel & Kjær
Measuring Object: Rumble Filters in Type 4416
Recording No.:
Sign.: JAH
Date: 27-7-75
Potentiometer:
Zero Level:
D A B C lin.
dB
Rumble A
Rumble B
2 Hz 5 10 20 50 100 200 500 1000 2000 5000 10000 20000 50000 100000
QP 1143 Pot. Range: 50 dB Rectifier: RMS Lower Lim. Freq.: 2 Hz Writing Speed: 8 mm/sec. Paper Speed: 1 mm/sec.
750635

Fig.3. Standardized rumble curves

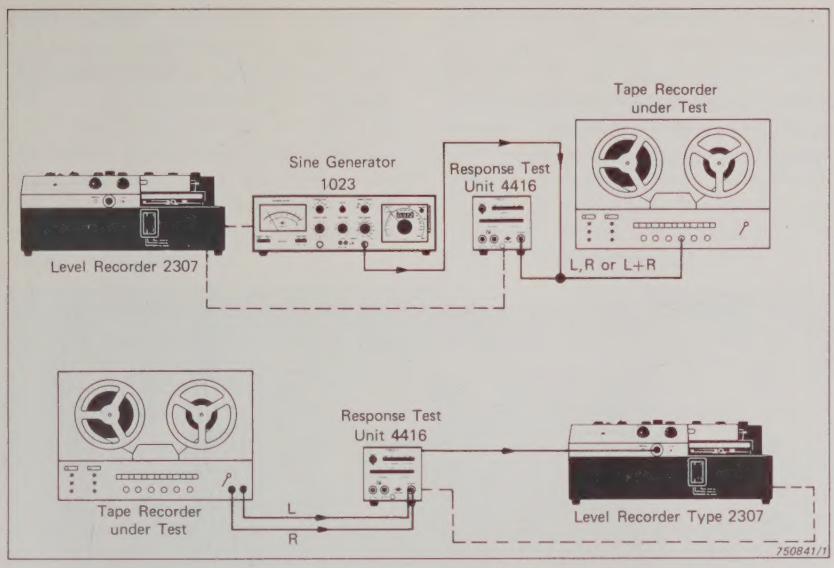

Fig.4. Recording and playback of test tape utilizing the Response Test Unit

vice under test, use is made of the LIN position giving no correction to the signal.

2) Where measurements are made on unequalized signals using test records cut to the IEC standard, the IEC position, introducing the standard equalization for record players must be used.

3) Where the B & K test records are used, the "Boost, 75 μs" equalization must be applied, regardless of the setting of the other selectors, because of the special pre-emphasis used on these records. (The reason for and the nature of the B & K pre-emphasis are explained in the section on test records.)

The third input, for tape recorder testing, bypasses these equalization networks.

For monitoring purposes, an output is available after the equalizing circuits.

After the equalization networks, the signals are fed to an adder and a chopper making available, via a selector, a total of four different signals. The chopper operates at a frequency of approx. 1 Hz and is suitable for very detailed analysis of the stereo balance as a function of frequency, and allows graphic records to be made automatically on the Level Recorder Type 2305 or 2307. The three remaining positions of the selector, enabling measurement on the Left and Right channels separately and on the sum signal, should need no further explanation.

After passing the adder and chopper, the signal may be applied directly to the output or it may be weighted in one of the standardized rumble filters. The direct route is used for frequency response, crosstalk, balance and other measurements on the pick-up cartridge while the weighted positions are used for measurements of turntable quality.

For automatic swept distortion measurements, an output to the Tracking Frequency Multiplier Type 1901 is available via a noise filter.

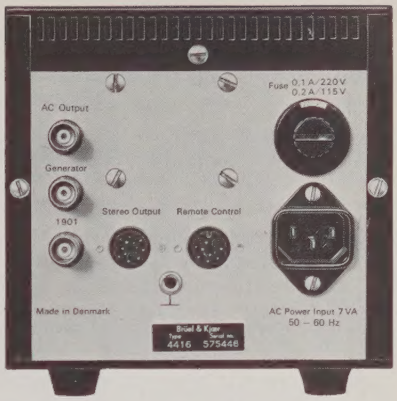

Fig.5. Rear view of Type 4416

Type 1901 is able to control the tuning of the B & K Heterodyne Analyzer Type 2010 or Heterodyne Slave Filter Type 2020 in such a way that their filters automatically follow almost any desired harmonic component in the measured signal. The noise filter is necessary in order to avoid disturbance of the tracking due to clicks and surface noise. For intermodulation measurements, a Distortion Measurement Control Unit Type 1902 can be added to a set-up with the Analyzer Type 2010.

The synchro-starter circuit is used to obtain synchronization between the recorded signals and the frequency calibrated paper used with the Level Recorders. All relevant bands on the B & K Test Records are preceded by a short, sine signal of 1000 Hz. The synchro-starter circuit detects the trailing edge of this tone burst and starts the Level Recorder when the tone ceases.

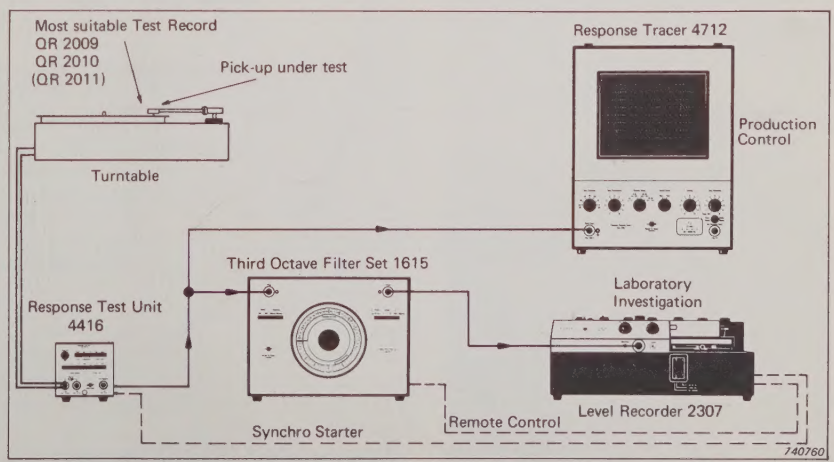

Fig.6. Set-up for production control or laboratory examination of a pick-up cartridge. The Filter Set Type 1615 is used to increase the signal/noise ratio

When measurements are made on tape recorders, dictation machines etc., a frequency sweep preceded by a 1 kHz tone can be recorded automatically by means of a B & K Sine Generator Type 1023 driven by a Level Recorder Type 2305 or 2307 which is started by the synchrostarter in the 4416. Where a fast display of frequency response curves is desired, for instance in production control, the Frequency Response Tracer Type 4712 can be used. This instrument does not require a synchronization signal.

Test Records

General

A very obvious way to test the performance of a pick-up cartridge is to replay a record where a number of different signals with well defined characteristics have been accurately recorded. By examining the electrical output, it can be seen how the pick-up performs under exactly the same conditions as are met when it replays ordinary records.

It is well known that ordinary speech and music programmes contain only limited power at higher frequencies. Therefore, when making disc recordings, the upper frequency region is given the greatest gain and the lower the least. However, if a test programme were recorded through the usual pre-emphasis network, the reference level would be too low or recording of the high frequency part would be impossible. On QR 2009 and QR 2010 it was decided to omit the treble boost and use constant level from 1000 Hz. In spite of this, the stylus tip acceleration approaches 1000 g at the highest frequencies on QR 2010.

The materials for the three test records available from Brüel & Kjær are selected and treated with great care in order to obtain the best possible mechanical properties and a very low surface noise level.

The test records are sold in boxes of five.

Test Record QR 2009

This Test Record is designed for production control of pick-ups. As can be seen from the programme on page 7, it contains four sweeps from 20 Hz to 20 kHz each with a particular type of modulation. This signal sequence is repeated twice on each side of the record. If a pick-up test is started with band number 1, the pick-up automatically proceeds through bands 2, 3 and 4 and then stops. The Level Recorder has then also stopped and is ready to receive the new synchronization burst when it arrives from the pick-up. If it is desired to record the response to more than one modulation type on the same piece of re-

All rights reserved
B K
Brüel & Kjær
Copenhagen Denmark
Stereophonic
Gliding Frequency Record
20-20 000 Hz
Type QR 2009
St 45
Frequency Sweeps: Logarithmic 20 Hz to 20 kHz in 50 seconds
Start Marking (20 Hz point): Cease of the 1 kHz signal preceeding each band
Recording Characteristic: IEC Publication 98 without treble emphasis
(constant velocity above 1 kHz)
Recorded Velocity at 1 kHz: 2.24 cm/s r.m.s. in 45° modulation
(3.16 cm/s in lateral and vertical modulations)
Bands 1 and 5: 45° left modulation (A)
Bands 2 and 6: 45° right modulation (B)
Bands 3 and 7: lateral modulation (A+B)
Bands 4 and 8: vertical modulation (A–B)
Recorded on ORTOFON Equipment

cording paper, it is done by rewinding the paper strip after the recorder has stopped and placing the pick-up at the beginning of the desired band. The sweep duration on all bands is 50 s and the recording characteristics plus all other data are in accordance with IEC R 98 and R 98-1, except for constant velocity above 1000 Hz.

Test Record QR 2010

This Test Record is designed for laboratory measurements on pick-up units and for detailed investigations on production samples. Modern pick-ups are of extremely lightweight construction with very large compliance and wide frequency range — but also with a wide spread in specifications. Therefore, testing of production samples is an excellent means of maintaining a high and stable level of quality.

The two sides of QR 2010 are identical and the programme can be seen on page 7. Bands 8, 11 and 15 are designed to perform various measurements on record players while the rest are for pick-up measurements.

Bands 3 to 7 incl. are designed to determine the maximum velocity which a pick-up stylus can be given via a recorded signal. If the stylus cannot follow the groove, a high degree of distortion will occur, in severe cases the stylus will jump out of the groove.

Band 9 is for polarity check of the leads to the pick-up after first having checked that the L signal occurs when the L-button is pressed and vice versa. If the polarity is correct, the signal on the L + R output of Type 4416 will disappear when the pick-up passes the L—R signal. If they are reversed the opposite will occur.

Bands 10 and 12 are both intended for crosstalk measurement when only a voltmeter is available. First, a calibration signal is applied to the channel which is connected to the voltmeter. Then the measuring signal occurs in the other channel. The two signals have a difference in level which, in most cases, makes it unnecessary to change the voltmeter attenuator position.

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B K
Stereo Test Record
5 Hz - 45 kHz
Band 1, 2: L, R: 20 Hz - 45 kHz log. sweep — 10 db
Band 3, 4, 5, 6, 7: L + R: 1 kHz + 8 dB, + 6 dB, + 4 dB, + 2 dB, 0 dB
Band 8: L + R: 3,15 kHz — 12 dB
Band 9: L, R, L + R, L — R, L + R: 1 kHz 0 dB
type QR 2010
St 33
Band 10: L, R, R, L: 30 kHz — 20 dB, — 10 dB, — 20 dB, — 10 dB
Band 11: L + R: 315 Hz — 11,3 dB (— 6 dB w. Eql.) - Silent groove
Band 12: R, L: 400 Hz - 10 kHz log. sweep 0 dB
Band 13, 14: L, R: 20 Hz - 20 kHz log. sweep — 10 dB
Band 15: L + R: 5–20 Hz log. sweep — 20 dB
Ref. level 10 cm/sec RMS lateral at 1 kHz
Recording characteristic IEC
Publ. 98 (constant velocity above 1 kHz)
Cutting angle 20°
Recorded on ORTOFON Equipment

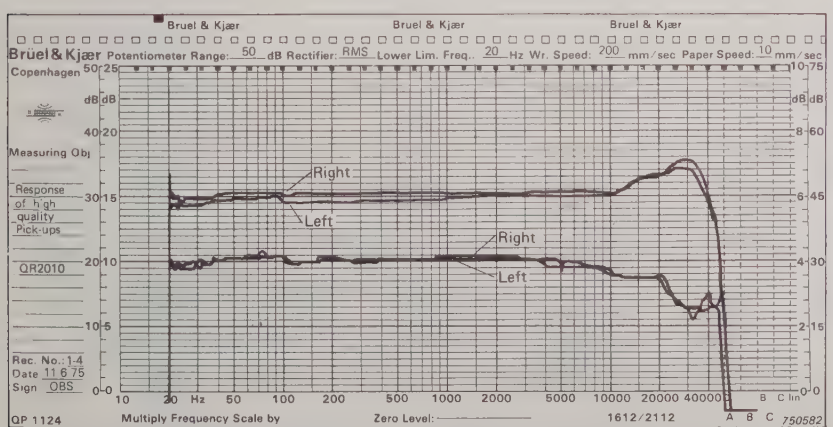


Fig.7. Response of two modern, high quality pick-ups to the 20 Hz to 45 kHz sweep on QR 2010. The vertical displacement is not due to different sensitivities but was arranged for clarity

Test Record QR 2011

This Test Record is designed to test complete audio reproduction systems when they are installed in the actual listening room. Too often, it is found that the ultimate quality is more influenced by the acoustic properties of the room than by the amount spent on the electronics. Therefore, this record was designed to provide users and dealers of Hi-Fi equipment with an inexpensive and easy-to-use tool, which gives accurate and reliable results for a quality evaluation. The signal consists of pink-weighted, random noise fed through a 1/3 octave filter which is stepped through the entire audio range. The measurement takes place from the user's favourite listening position, where a Sound Level Meter is placed. (The Types 2206 and 2203 are recommended.) On the frequency calibrated paper QP 2011, supplied with the records, the total system response is plotted from the Sound Level Meter readings. Since the measurements take place in the actual listening room, its acoustic behaviour is automatically taken into account.

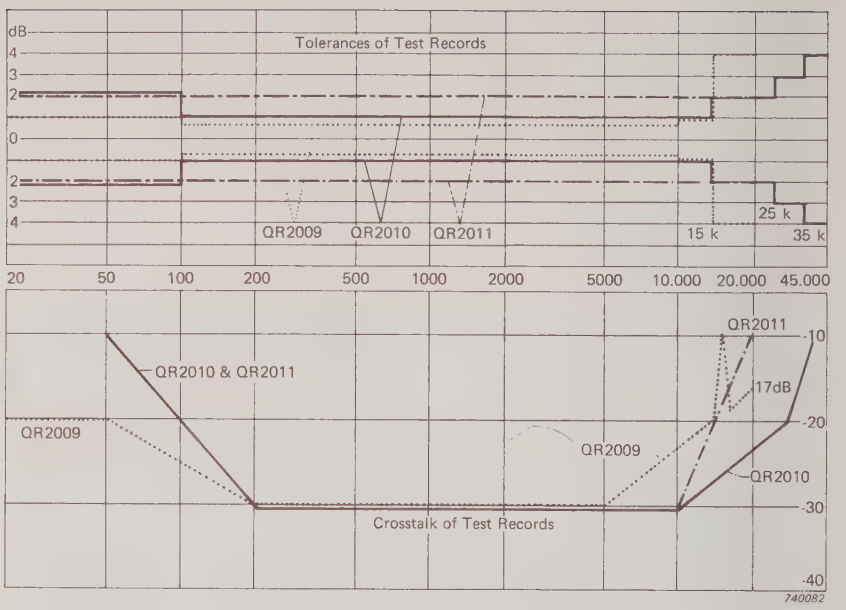
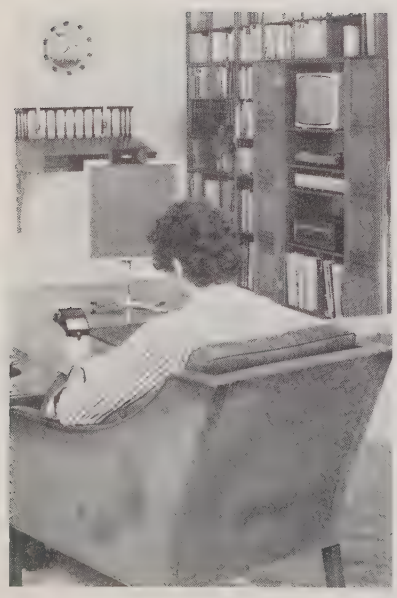


Fig.8. Tolerances and crosstalk of the test records



B K
Brüel & Kjær
Nærum, Denmark
Pink Noise Test Record B
Type QR 2011 St 33
Band 1 L+R, Calibration
Band 2 L+R, Measuring Signals
Band 3 L+R, Measuring Signals
Band 4 L+R, } Total Phase Check
Band 4 L−R, }
Band 5 L+R, Individual Phase Check
Band 6 L+R, Sine Sweep
Band 7 L+R, Wide Range Distribution
All rights reserved

	Band No	Type of Modulation	Level*)	Accuracy	Frequency	Duration	Sync Burst	Remarks	Applications
QR 2009	1 & 5	Left	10 dB	± 1 dB	20 Hz to 20 kHz log sweep	16,7 s/dec , total 50 s	Yes	For sweep accuracy and crosstalk see Fig 8	Frequency response, cross-talk and balance measure-ments
	2 & 6	Right							
	3 & 7	L + R							
	4 & 8	L − R							
QR 2010	1	Left	10 dB	+ 1 dB	20 Hz to 45 kHz log sweep	5 s/dec total 16,7 s	Yes	For sweep accuracy and crosstalk see Fig 8	Frequency response and cross-talk measurements
	2	Right							
	3	L + R	+ 8 dB	± 0,5 dB	1 kHz	15 s each	No	Distortion < 4%	Determination of maximum tracking ability
	4	L + R	+ 6 dB					Distortion < 3%	
	5	L + R	+ 4 dB					Distortion < 1%	
	6	L + R	+ 2 dB					Distortion < 1%	
	7	L + R	0 dB					Distortion < 1%	
	8	L + R	12 dB	± 1 dB	3150 Hz	60 s	No	Max Wow < ±0,06% (peak, weighted)	Wow measurements on turn-tables
	9	Left	0 dB	± 0,5 dB	1 kHz	3 s	No		Quick polarity check
		Right				3 s			
		L + R				1 s			
		L − R				1 s			
		L + R				1 s			
	10	Left	−20 dB	+ 2 dB	30 kHz	5 s each	No	Crosstalk > 20 dB	Crosstalk measurements at 30 kHz in 4-channel transdu-cers
		Right	−10 dB						
		Right	20 dB						
		Left	−10 dB						
	11	L + R	−11,3 dB	+ 1 dB	315 Hz	15 s	No	Rumble according to IEC-method: A-Weighting < 50 dB B-Weighting < 65 dB	Rumble measurements on turntables
		Empty				60 s	No		
	12	Left	20 dB	± 1 dB	1 kHz	3 s	No	Crosstalk > 20 dB > 30 dB at 1 kHz	Crosstalk measurement re-quiring only an AC-voltmeter
		Right	0 dB		1 kHz	2 s			
		Right	0 dB		400 Hz to 10 kHz log sweep	5 s/dec total 7 s			
		Right	−20 dB		1 kHz	3 s			
		Left	0 dB		1 kHz	2 s			
		Left	0 dB		400 Hz to 10 kHz log sweep	5 s/dec total 7 s			
	13	Left	−10 dB	± 1 dB	20 Hz to 20 kHz log sweep	5 s/dec total 15 s	Yes	For sweep accuracy and crosstalk see Fig 8	Measurement of response and crosstalk at small me-chanical wavelengths
	14	Right	10 dB						
	15	L + R	20 dB	± 2 dB	5 Hz to 20 Hz log sweep	50 s/dec total 30 s	Yes	Constant velocity	Investigations of arm reso-nances
QR 2011A	1	Left	−22 dB	± 1 dB	1 kHz, 1/3 oct Noise	60 s	No	At the beginning of each band a voice states centre frequency	Calibration
	2	Left			20 Hz to 20 kHz, 1/3 oct Noise	500 s	Yes		Manual response measure-ment in listening room
	3	Right			1 kHz, 1/3 oct Noise	60 s	No		Calibration
	4	Right			20 Hz to 20 kHz, 1/3 oct Noise	500 s	Yes		Manual response measure-ment in listening room
QR 2011B	1	L + R	−22 dB	± 1 dB	1 kHz, 1/3 oct Noise	60 s	No	At the beginning of each band a voice states centre frequency	Calibration
	2	L + R			20 Hz to 20 kHz, 1/3 oct Noise	500 s	Yes		Manual response measure-ment in listening room
	3	L + R	22 dB	+ 1 dB	20 Hz to 20 kHz 1/3 oct Noise	150 s	Yes	No voice comments	Automatic response measure-ment in listening room
	4	L + R	24 dB	+ 1 dB	20 Hz to 20 kHz, Wideband Noise	30 s each	No	Correct phase	Phase check of the entire system
		L − R						Reversed phase	
	5	L + R	−22 dB	± 1 dB	20 Hz to 1 kHz, Noise	15 s each	No		Individual phase check
		L + R			1 kHz to 4 kHz, Noise				
		L + R			4 kHz to 20 kHz, Noise				
	6	L + R	10 dB	± 1 dB	20 Hz to 1 kHz, Sine	85 s	Yes		Tracing resonating parts
	7	L + R	24 dB	+ 1 dB	20 Hz to 20 kHz, Wideband Noise	240 s	No		Room distribution of wide range signal

*) Relative to 10 cm/s RMS, Lateral (L + R) at 1000 Hz

Specifications 4416, QR 2009, QR 2010 and QR 2011

RESPONSE TEST UNIT 4416

Pick-Up Inputs:
High Level:
Impedance: 1 MΩ//max. 15 pF
Max. Voltage: 1,5 V peak
Low Level:
Impedance: 47 kΩ//max. 15 pF
Max. Voltage: 15 mV peak

Tape Input:
Impedance: 47 kΩ//max. 25 pF
Max. Voltage: 5 V peak

Gain at 1 kHz:
High Level Input: 10 dB
Low Level Input: 50 dB
Tape Input: 0 dB
Accuracy: ± 0,3 dB

Frequency Range:
5 Hz to 50 kHz ± 0,3 dB incl. filters

Balance Between Channels:
Better than 0,2 dB

Equivalent Input Noise:
High Level Input: < 0,5 mV
Low Level Input: < 10 μV
Tape Input: < 1 mV

Equalization:
1. LIN: Linear 5 Hz to 50 kHz
2. LIN + Boost: 75 μs
3. IEC: 75/318/3180 μs
4. IEC + Boost: 318/3180 μs
IEC curve in accordance with IEC 98, DIN 45547, B.S. 1928:1961 and several other standards

Rumble Filters:
A and B weighting in accordance with IEC 98 A and DIN 45539. See Fig.3

Equivalent Input Noise with Rumble Measurements:

	Low Level	High Level
A-filter:	< 3 μV*)	< 300 μV
B-filter:	< 1 μV	< 100 μV

Harmonic Distortion:
General Condition V_o: = 1 V_{RMS}
LIN + Boost and IEC:
< —60 dB, 20 Hz to 20 kHz
< —50 dB, 5 Hz to 50 kHz

All other Curves:
< —70 dB, 20 Hz to 20 kHz
< —60 dB, 5 Hz to 50 kHz

Nonlinear Distortion:
Measured in accordance with IEC 268-3 and DIN 45403 at Vo = 1 V

IM Distortion:
Typically no sidebands will exceed:
—70 dB, 20 Hz to 20 kHz
—60 dB, 5 Hz to 50 kHz
(all curves)

Difference Frequency Distortion:
Typically no sidebands will exceed:
—55 dB, 20 Hz to 20 kHz
(IEC and LIN + Boost)
—70 dB, 20 Hz to 20 kHz
—60 dB, 5 Hz to 20 kHz
(all other curves)

Crosstalk:
Measured in the channel with input shorted

	1 kHz	20 kHz	50 kHz
Pick-up 47 kΩ:	70 dB	45 dB	35 dB
Pick-up 1 MΩ:	65 dB	40 dB	30 dB
Tape:	70 dB	45 dB	35 dB

Synchrostarter:
Automatic or Manual. Sensitive to signal as follows:
Frequency: 1000 ± 50 Hz
Duration: > 100 ms
Voltage: > 10 mV (Pick-up)
> 100 mV (Tape Recorder)

Output Voltage:
Max. 5 V peak

Output Impedance:
AC Output: < 150 Ω, R_{LOAD} min. 10 kΩ
Stereo Output: 4,7 kΩ

Power Supply:
100 to 240 V AC ± 10%
50 to 60 Hz

Dimensions:
Width: 139,5 mm (5,5 in)
Height: 132,6 mm (5,2 in)
Depth: 200 mm (7,9 in)
(B & K module cabinet KK 0024, 4/12 of 19" rack module)

Accessories Included:
Remote Control Cable AQ 0038 for level Recorder 2305

Accessories Available:
Remote Control Cable AQ 0035 for Level Recorder 2307

TEST RECORDS QR 2009, QR 2010 AND QR 2011
Delivered in boxes of five

Diameter:
301,6 mm (11,875 in)

Diameter of Centre Hole:
7,3 mm (0,287 in)

Speed of Rotation:
QR 2009: 45 rev./min.
QR 2010: 33 1/3 rev./min.
QR 2011: 33 1/3 rev./min.

Cutting Angle:
QR 2009: 0°
QR 2010: 20°
QR 2011: 15°

Program and Accuracy:
See scheme page 7

Recording Characteristic:
In accordance with IEC, RIAA, NAB, BS and DIN recommendations and standards. QR 2009 and QR 2010 are recorded with constant velocity above 1 kHz (No treble emphasis, see text)

Broad-band and Surface Noise:
QR 2009 more than 32 dB below ref. level
QR 2010 more than 45 dB below ref. level
QR 2011 more than 45 dB below ref. level
Increased to 65, 75 and 75 dB respectively below ref. level by filtering through 1/3 octave filters

*) If the instrument is placed in a 50 Hz magnetic field of 100 A/m this figure is increased to < 10 μV. All other specifications are unchanged

2. CONTROLS

2.1. FRONT PANEL

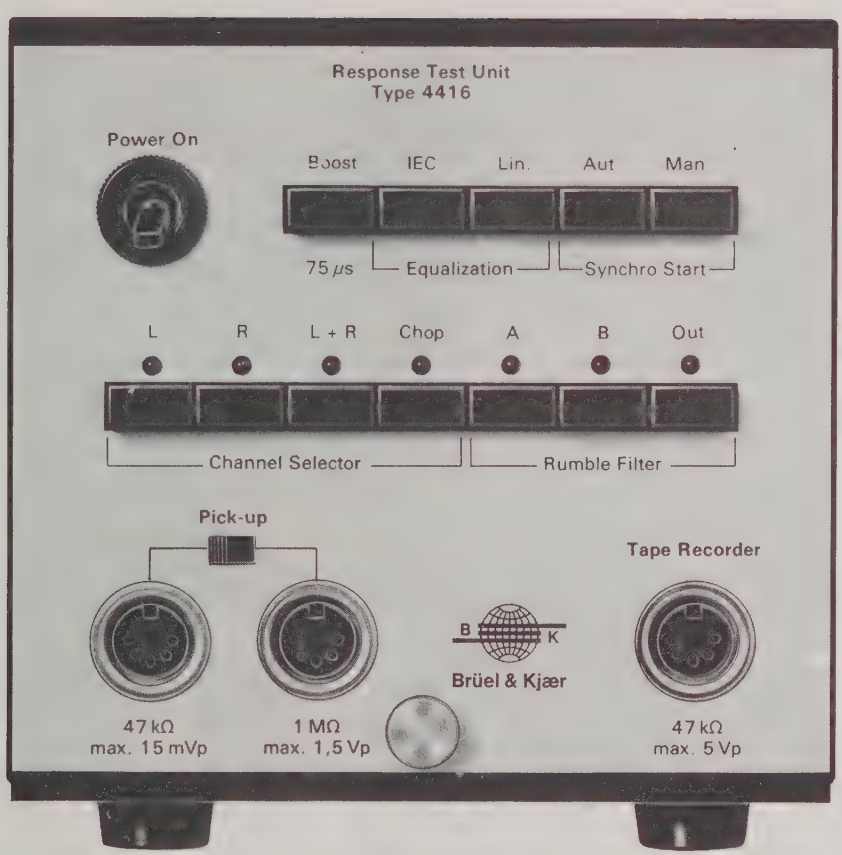


Fig.2.1. Front Panel of Type 4416

POWER ON: Toggle switch for turning the instrument on and off. The up position is on.

EQUALIZING SELECTOR: Three two-position push-button switches for selection of the required equalization network when the switch is set to its inner position, as follows:

"Boost, 75 μs": selects the de-emphasis mode which should be used when measurements are being made from B & K test records, because

of their special pre-emphasis. (See Chapter 1.) This push button may be used independently of the other two, and is not reset by them.

"IEC": selects the de-emphasis mode which should be used on un-equalized signals from records cut to the IEC standard. This switch is interlinked with the "Lin." switch, so that depressing the "Lin." switch releases the "IEC" one, and vice versa. For tape-recorder testing, this push button should be in its outer position.

"Lin.": selects the mode without any de-emphasis, for use with signals which are already equalized, such as those from the preamplifier of a record player. This switch is interlinked with the "IEC" switch, so that depressing the "IEC" switch releases the "Lin." one, and vice versa. For tape-recorder testing, this push button should be in its outer position.

SYNCHRO START:

Two push-button switches for control of the synchrostarter. Selection is made by depressing the required push button, provided the Level Recorder is connected to the 4416 by a control cable, as follows:

"Auto.": with this two-position push button depressed, a Level Recorder Type 2305 or 2307 may be started automatically by the cessation of a 1 kHz tone from the test record (or tape); the recording is then synchronized with the test record (or tape). This switch is released by depressing it a second time.

"Man.": by momentarily depressing this switch, the Level Recorder Type 2305 or 2307 may be started manually as required. As soon as the switch is released, the Level Recorder will start.

CHANNEL SELECTOR:

A set of four momentary-contact push-button switches with the following functions:

"L": with this push button selected, only the signal from the left-hand channel of the (stereo) system is passed through the 4416 for further analysis.

"R": with this push button selected, only the signal from the right-hand channel of the (stereo) system is passed through the 4416 for further analysis.

"L + R": with this push button selected, the signals from both channels are added together and passed through the 4416 for further analysis. (This position is automatically selected when the 4416 is turned on.)

"Chop": with this push button selected, the signals from the left-hand and right-hand channels are alternately passed through the 4416 at intervals of about half a second. The chop frequency is internally adjustable from about 0,5 Hz to 10 Hz. (In fact higher frequencies are available, but are not recommended.) See Service Manual.

When one of the push buttons is touched, the red LED just above it is illuminated, and the function which was selected previously is disconnected.

RUMBLE FILTER:

A set of three momentary-contact push-button switches with the following functions:

"A": with this push button selected, the standardized rumble filter A (see Chapter 1, Fig.3) is applied to the signal.

"B": with this push button selected, the standardized rumble filter B (see Chapter 1, Fig.3) is applied to the signal.

"Out": with this push button selected, the signal is not subjected to either of the rumble filters, but is passed directly to the output. (This position is automatically selected when the 4416 is turned on.)

When one of the push buttons is touched, the red LED just above it is illuminated, and the function which was selected previously is disconnected.

PICK-UP:

Two five-pin screw-in DIN sockets and a two-position slide switch, which are used as follows:

"47 kΩ, max. 15 mVp": an input socket for the signal from a magnetic cartridge, providing the necessary matching and amplification. Accepts B & K plug JP 0504. Input impedance and maximum voltage are as stated by the socket. For pin connections, see Fig.2.2.

"1 MΩ, max. 1 Vp": an input socket for the signal from a piezoelectric (ceramic) cartridge, providing the necessary matching and amplification. Accepts B & K plug JP 0504. Input impedance and maximum voltage are as stated by the socket. For pin connections, see Fig.2.2.

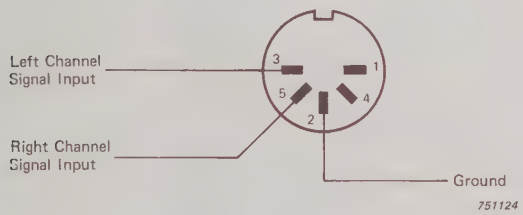


Fig.2.2. PICK-UP sockets. External view

The two-position switch should be in the left-hand position for the magnetic cartridge input and the right-hand position for the piezoelectric cartridge input. One switch position disconnects the other PICK-UP input. (The TAPE RECORDER input is also connected continuously, however.)

TAPE RECORDER:

A five-pin screw-in DIN socket for the signal from a tape recorder. This input is always connected. Accepts B & K plug JJ 0501. The input impedance is 47 kΩ; the maximum input voltage is 5 Vp. When using this input, the "Lin." and "IEC" EQUALIZING SELECTORs should be "out" to keep noise from the other inputs to a minimum. This socket is also used for recording signals onto tape, since it is directly connected to the GENERATOR input socket on the rear panel. For pin connections, see Fig.2.3.

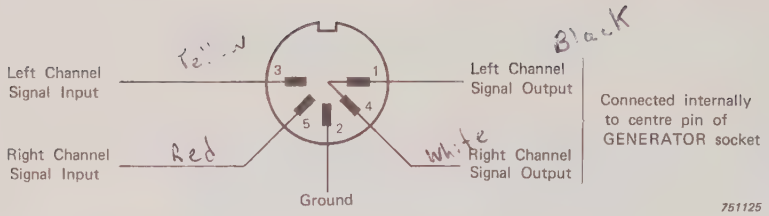


Fig.2.3. TAPE RECORDER socket. External view

2.2. REAR PANEL

Fig.2.4. Rear Panel of Type 4416

AC OUTPUT: A BNC socket which is used to connect the selected output ("L", "R", "L + R" or "Chop") to the Level Recorder input. Accepts plug JP 0035.

GENERATOR: A BNC socket which is used to receive an input signal from a generator to record signals for measurements on a tape recorder. This socket is connected directly to the TAPE RECORDER input socket on the front panel. Accepts B & K plug JP 0035.

TO 1901: A BNC socket giving a noise-filtered signal output for connection to a

Tracking Frequency Multiplier Type 1901 for automatically swept distortion measurements. Accepts plug JP 0035.

STEREO OUTPUT: A seven-pin DIN socket which gives an output signal (taken just after the internal equalization networks) for monitoring purposes. For pin connections, see Fig.2.5.

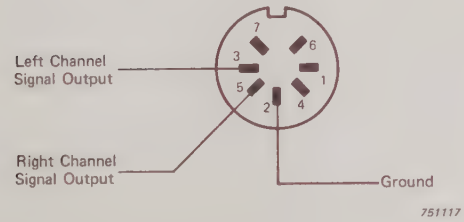


Fig.2.5. STEREO OUTPUT socket. External view

REMOTE CONTROL: A seven-pin DIN socket providing the facilities for automatic or remote-manual starting and stopping of a Level Recorder Type 2305 or 2307. Accepts cable AQ 0035 for control of 2307, or cable AQ 0038 for control of 2305 (and also switching of an external filter by the 2305). See sections 3.3.1 and 3.3.2 for details of pin connections.

AC POWER INPUT: Three-pin socket for the connection of an AC power supply of between 100 and 240 V AC. Power consumption is approximately 7 VA. Accepts cable AN 0010. For connection of an AC supply, see Fig.2.6.

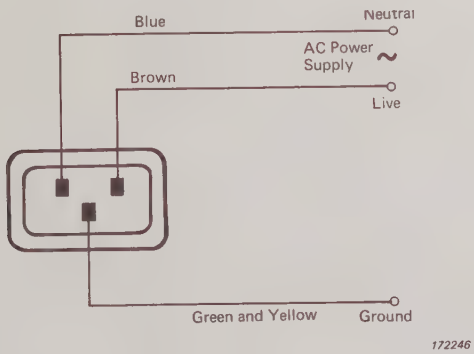


Fig.2.6. AC POWER INPUT socket

FUSE AND VOLTAGE SELECTOR: Contains a 0,1 A fuse (20 × 5 mm) for 200 — 240 V use. A 0,2 A fuse should be used for lower voltages. To remove the fuse, unscrew the black central knob, and pull it straight out. To change the mains voltage setting, remove the fuse and then pull the black bush straight out. Replace the bush so that its pin fits into the socket corresponding to the appropriate mains voltage. The voltage selected now shows in the window of the bush. Replace the fuse, and screw the central black knob back again.

3. OPERATION

3.1. INTRODUCTION

The Response Test Unit Type 4416 may be used to test the turntable and pick-up (and in some cases the preamplifier) of a record player, or the characteristics of a tape recorder or other similar device.

For the former, three test records are available from Brüel and Kjær, QR 2009, QR 2010, and QR 2011, specially designed for this type of test. The 4416 gives the correct de-emphasis from these (and other) records, provides synchronized starting and stopping signals to a Level Recorder, acts as a channel selector, and provides rumble filters (and a noise-filtered output to a tracking filter).

For the latter, the 4416 acts as an interface between a suitable generator and the tape recorder for recording a reference signal, and then provides synchronization signals to a Level Recorder for playback, and acts as a channel selector.

3.2. TURNTABLE AND PICK-UP TESTING USING B & K TEST RECORDS

3.2.1. General

Care of Test Records

All test records are extremely sensitive to improper handling, and must be treated with the utmost care. For example, fingers should not touch the playing surfaces, the records should be carefully stored and not subjected to extreme temperatures. Furthermore, they should be kept scrupulously clean and free from dust so that drop-out is avoided (the use of antistatic record cleaners is recommended). The number of playings which can be made without alteration of the characteristics is greatly dependent on the care exercised in the use of records. However, by conserving one record side as a reference (or a complete record in the case of the QR 2011), it will be possible to check the service life of each record in use.

It is of course of prime importance to check the reproducing stylus tip and the tracking weight before each record playing. The stylus should be free from dust, etc., and the tip radius should be between 12 and 18 μm (0,0005 and 0,0007 in), or 26 μm (0,001 in) in the case of lateral bands, which are cut with an included angle of 40° to 50°. The records are cut in accordance with IEC Recommendation 98, which is recognised by most countries. All modulations are sinusoidal (except for the QR 2011 which contains noise bands) with negligible distortion. (See also Chapter 1 for further details.)

Turntable Requirements

Where reproducing heads and cartridges are being tested separately (i.e. when the ef-

fects of the turntable are not required), a good professional turntable should be selected, especially as far as low-frequency measurements are concerned, because of the predominant influence of wow and rumble. The rotational speed should be adjusted carefully using a stroboscopic comparison with the mains frequency, or other methods, as preferred. It is also recommended that the turntable (and possibly the preamplifier) be isolated from external vibrations. This may be done very efficiently by suspending the table supporting the two devices from the ceiling by four rubber tubes. (Another possibility is the use of electrical high-pass filters, but care should be taken to ensure that they do not affect the frequencies of interest for the recording.)

Since the test frequency and velocity levels on records QR 2009 and QR 2010 are proportional to the rotational speed, it is possible to extend the frequency range of the tests by using different rotational speeds, but it is then necessary to modify the equalization networks accordingly to give the required characteristics.

Play-back Loss

At high frequencies, the acceleration which is communicated to the reproducing stylus attains a few hundred g (gravity). Consequently, even if the stylus mass has been reduced to a minimum, the reaction of the stylus on the record may cause non-negligible elastic deformations of the groove walls. This phenomenon which, in most cases corresponds to a reduction of amplitude and velocity of the stylus movement, is commonly called "play-back loss".

The play-back losses are greatly dependent on the construction of the reproducing pick-up. They may be negative as well as positive and cannot be determined without accurate knowledge of the mechanical constants involved. A theoretical investigation of the phenomenon (B & K Technical Review No.3-1962, Appendix A) shows that play-back losses (or gains) increase rapidly with frequency in all cases. Practically, play-back losses attaining a few dB at 20 kHz are observed when tracking the inner bands of the Gliding Frequency Records with a commercial pick-up of good quality.

Translation Loss

At the outer and inner parts of the record (major and minor diameters), the stylus does not have the same groove velocity. (This velocity is directly proportional to the distance from the centre of the record.) Because of this, a given frequency will not have the same mechanical wavelength at the outer and inner grooves. On the record QR 2011, for example, the 20 kHz signal has a wavelength of 20 μm in the L + R band, and 12 μm in the R band. Typical styli might have a tip radius between 7 μm and 18 μm. Thus, at a certain distance from the centre of the record, the stylus tip will be unable to reach the bottom of the groove, so the amplitude of the signal from the stylus and pick-up will be reduced, although the recorded level on the record is correct. This is called "translation loss". Typical attenuations of around 10 dB at 20 kHz might be expected, depending on the stylus tip dimensions, when playing the inner bands of a record. In practice, translation loss is considerably more important than play-back loss in giving high-frequency roll-off. A typical example of translation loss is seen by comparing Figs.3.1 and 3.2.

Pinch Effect

When a record is produced, it is normally cut with a triangular cutter (see Fig.3.3). This has the effect of making the groove wider at the points where the cutter is perpendicular to the groove. When playback is effected using an elliptical stylus, the points of contact

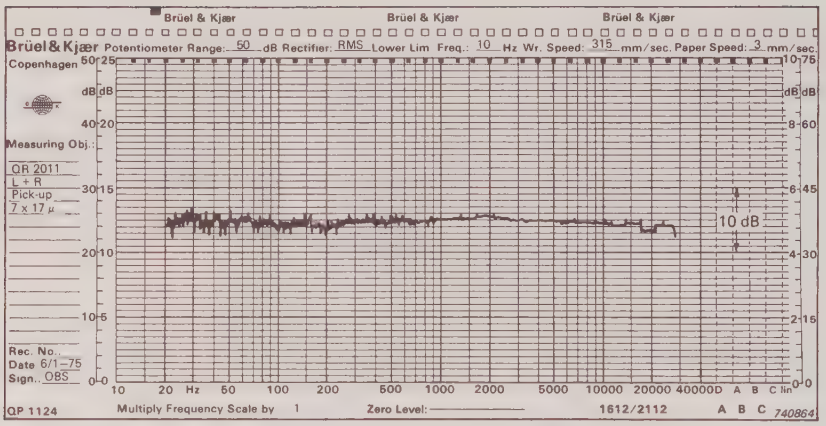

Brüel & Kjær
Brüel & Kjær Potentiometer Range: 50 dB Rectifier: RMS Lower Lim Freq.: 10 Hz Wr. Speed: 315 mm/sec. Paper Speed: 3 mm/sec.
Copenhagen
Measuring Obj.:
QR 2011
L + R
Pick-up
7 x 17 µ
Rec. No.:
Date 6/1–75
Sign. OBS
10 dB
10 20 Hz 50 100 200 500 1000 2000 5000 10000 20000 40000D A B C lin.
QP 1124
Multiply Frequency Scale by 1
Zero Level:
1612/2112
740864

Fig.3.1. Typical pick-up frequency response with negligible translation loss

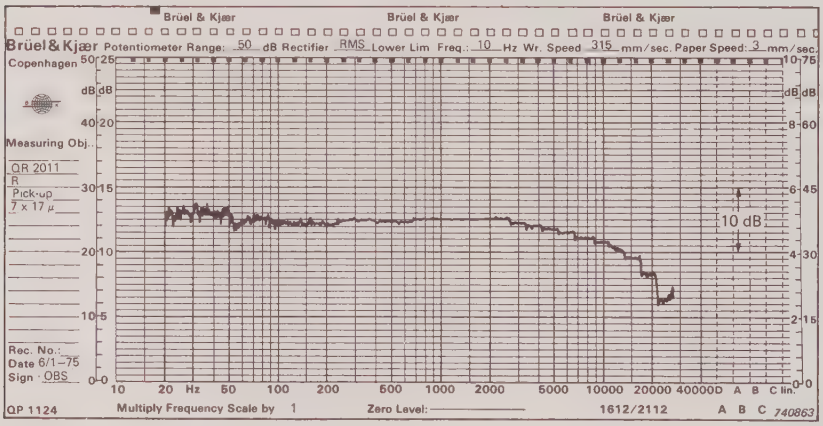

Brüel & Kjær
Brüel & Kjær Potentiometer Range: 50 dB Rectifier RMS Lower Lim Freq.: 10 Hz Wr. Speed 315 mm/sec. Paper Speed: 3 mm/sec.
Copenhagen
Measuring Obj.:
QR 2011
R
Pick-up
7 x 17 µ
Rec. No.:
Date 6/1–75
Sign OBS
10 dB
10 20 Hz 50 100 200 500 1000 2000 5000 10000 20000 40000D A B C lin.
QP 1124
Multiply Frequency Scale by 1
Zero Level:
1612/2112
740863

Fig.3.2. Response of same pick-up as that used in Fig.3.1, but with translation loss

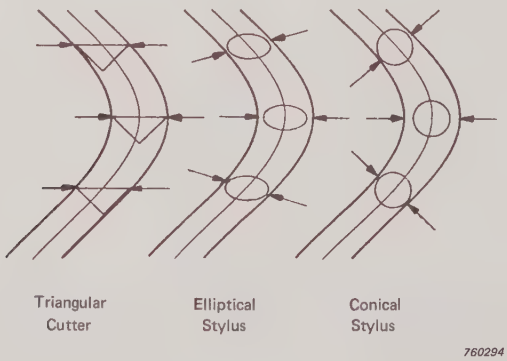


Fig.3.3. Demonstration of pinch effect

(indicated by arrows) turn and the stylus drops deeper into the groove at the widest point, and then rises again afterwards. This gives rise to vertical oscillation of the stylus at twice the recorded frequency. With a conical stylus, the situation is even worse, and

the vertical movement is more pronounced. When using the 4416, selection of the "L + R" mode will virtually cancel out signals arising from this "pinch effect". (A good description of this and other record-reproducing problems is given in the French "Hifi Magazine", No. 38, March 1976, pp. 134-140.)

3.3. USE OF B & K TEST RECORD QR 2009

3.3.1. Automatic Frequency-Response Plotting

To check the frequency response of the left channel, band 1 or 5 should be used, and the 4416 "L" CHANNEL SELECTOR depressed. To check the right channel, band 2 or 6 should be used, and the 4416 "R" CHANNEL SELECTOR depressed. Bands 3 and 4 or 7 and 8 may also be used for checking the frequency response of each channel. Once the record has been started, the first four (or the last four) bands will continue, and start the Level Recorder each time at the correct place. Only the 4416 CHANNEL SELECTOR need be changed as necessary.

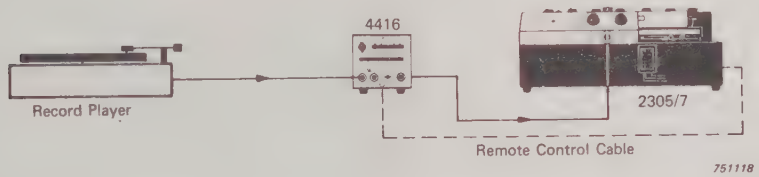


Fig.3.4. Set-up for automatic frequency-response plotting

1. Set up the instrumentation as shown in Fig.3.4, bearing in mind the following:

   a) Use the correct PICK-UP input to the 4416 for the cartridge used. Check if the pick-up has an equalized output or not, before choosing the EQUALIZING SELECTOR. If a preamplifier with standard equalization is built into the record player, and the output is taken from it, use the "1 MΩ" input, and set the equalization to "Boost 75 μs, Lin." for B & K records.

   b) The connection between the 4416 and the Level Recorder comes from the 4416 AC OUTPUT.

   c) The remote control cable should be connected to the REMOTE CONTROL sockets of the 4416 and Level Recorder. For the 2307, cable AQ 0035 should be used (although only the connections shown in Fig.3.5 are necessary); and for the 2305, cable AQ 0038 should be used (see Fig.3.6).

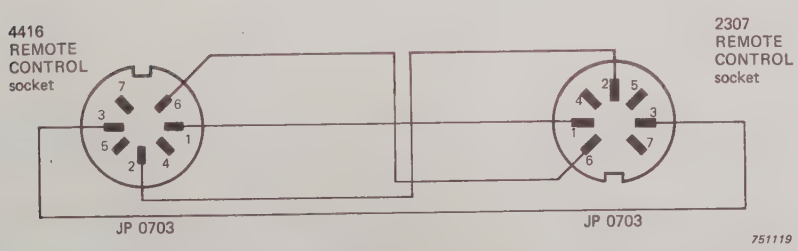


Fig.3.5. Synchrostarter cable for use with 2307. External view of sockets, soldering side of plugs, shown

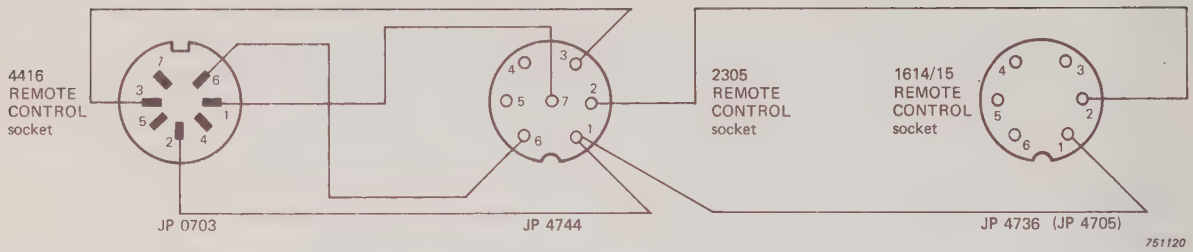


Fig.3.6. Synchrostarter cable AQ 0038 for use with 2305. External view of sockets, soldering side of plugs, shown

Note: When the Level Recorder is connected to the 4416 via the remote control cable, and the Level Recorder is set to run but not actually running (i.e. when it is waiting for the synchrostarter signal), intermodulation distortion is increased a little, possibly raising it above the —70 dB figure quoted in the specifications. (As soon as the Level Recorder starts, the level of distortion drops again.) Since this occurs for both record-player and tape-recorder testing, it is recommended that if there is a Level Recorder connected in the measuring system which is NOT being used, the remote control cable should be removed.

2. Set the controls of the 4416 as follows:

FUSE AND VOLTAGE SELECTOR:	As required
POWER:	"On"
EQUALIZING SELECTOR:	"Boost 75 μs" (for all B & K records)
	"IEC" or "Lin." as required (depends on pick-up and preamplifier)
SYNCHRO START:	"Auto."
CHANNEL SELECTOR:	As required
RUMBLE FILTER:	"Out"
PICK-UP switch:	As required

3. Set the controls of the Level Recorder as follows:

FUSE AND VOLTAGE SELECTOR:	As required
POWER:	"On"
POTENTIOMETER RANGE:	"50 dB"
RECTIFIER RESPONSE:	"RMS"
LOWER LIMITING FREQUENCY:	"20 Hz"
WRITING SPEED:	"200 — 500 mm/s"
PAPER DRIVE:	"Continuous F" (2307)
	"Start, Forward" (2305)
MOTOR:	"On" (2305)
PAPER SPEED:	"3 mm/s"
PEN DRIVE:	"On" (2307)

4. Adjust the position of the paper on the Level Recorder for correct synchronization (i.e. the sweep should start at 20 Hz). Consult the 2305 and 2307 Instruction Manuals if necessary.

5. Adjust the turntable rotational speed to exactly 45 r.p.m., check the stylus and tracking weight, and place the pick-up on a lead-in groove for playing the selected band of the record. Bands 1, 2, 5 and 6 are most suitable. (Since the pick-up response varies with groove velocity, a different response will be obtained from inner

and outer bands on a record. Thus a comparison of band 1 with band 5, or band 2 with band 6, etc., is a useful exercise.)

6. Adjust the level of the pen for the required deflection during the 1 kHz tone at the start of the band, using the Level Recorder INPUT ATTENUATOR and INPUT POTENTIOMETER.

7. The plotting of the frequency response will take place automatically when the 1 kHz start tone ceases. At the end of one trace, the pen should stop on the 20 Hz line of the paper again, ready for a subsequent recording.

For more detailed frequency-response analysis, a 25 dB or a 10 dB Potentiometer may be used, giving greater resolution. The only modification to be made in this case is to change the Level Recorder POTENTIOMETER RANGE knob from "50" to "25" or "10" respectively.

A typical frequency response using the instrumentation of Fig.3.4 is shown in Fig.3.7.

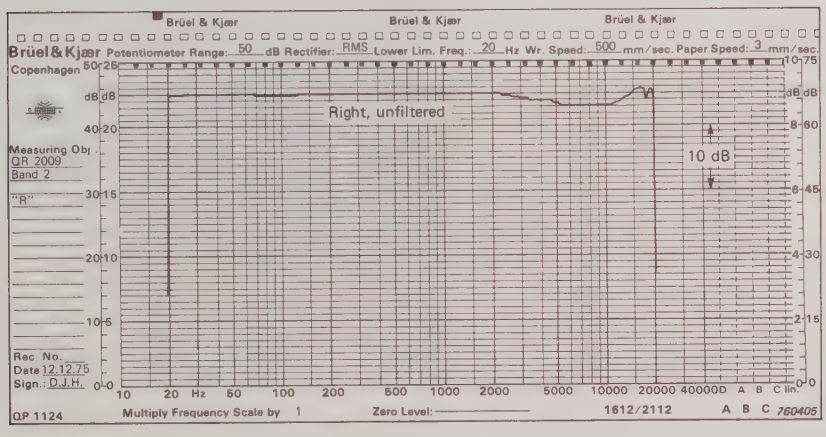


Fig.3.7. Typical frequency response of a pick-up

3.3.2. Automatic Selective Cross-Talk Measurements

To reduce the problems of surface noise during cross-talk measurements, a synchronous filtering of the signal is recommended, which increases the signal-to-noise ratio considerably. Either a Spectrometer 2113/14, or Filter 1614/15 and Measuring Amplifier Type 2606/07/08, may be used.

To check the cross-talk from the left channel to the right channel, band 1 or 5 should be used, and to check the cross-talk from the right channel, band 2 or 6 should be used. There are two possibilities: either to play each band twice, first recording on one channel and then the other (controlled by the relevant 4416 CHANNEL SELECTOR); or to make one recording using the 4416 "Chop" CHANNEL SELECTOR. The first method gives more detail, but the second is considerably quicker.

1. Set up the instrumentation as shown in Fig.3.8, bearing in mind the following:

   a) Use the correct PICK-UP input into the 4416 for the cartridge used. Check whether the pick-up has an equalized output before choosing the EQUALIZING SELECTOR. If a preamplifier with standard equalization is built into the record

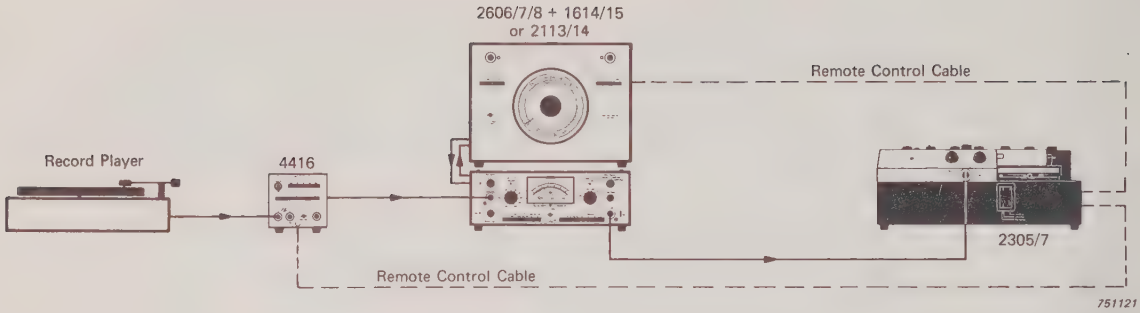


Fig.3.8. Set-up for automatic cross-talk measurements

player, and the output is taken from it, use the "1 MΩ" input, and set the equalization to "Boost 75 μs, Lin." for B & K records.

b) The connection between the 4416 and the Measuring Amplifier (or Spectrometer) comes from the 4416 AC OUTPUT.

c) The Filter is connected as an external filter to the Measuring Amplifier.

d) The remote control cables to be used are as follows:

For the filter switching from the 2307, use a cable as shown in Fig.3.9 from one 2307 REMOTE CONTROL socket, either on the rear or the side panel. The other cable AQ 0035 to the 4416 should be connected to the other 2307 REMOTE CONTROL socket.

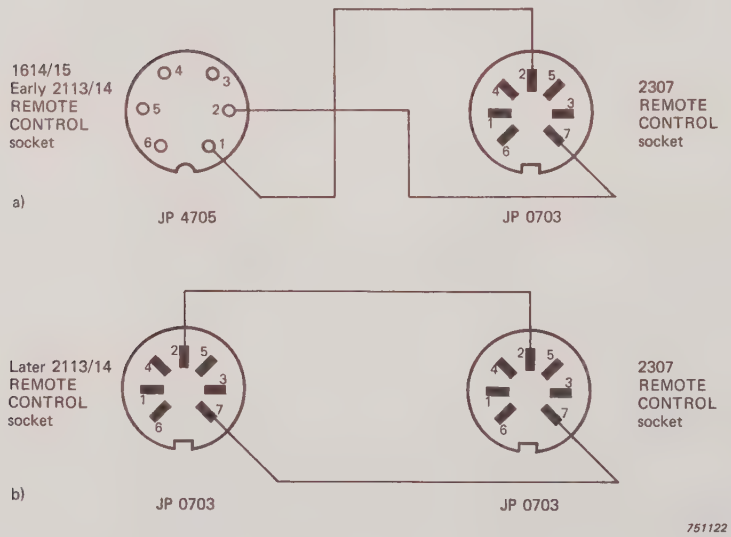


Fig.3.9. Remote control cables for switching Filters and Spectrometers. External view of sockets, soldering side of plugs, shown
(a) Band-Pass Filter Sets and early Spectrometers
(b) Later Spectrometers

The cable AQ 0038 (see Fig.3.6) should be used from the 2305 REMOTE CONTROL socket to those of the 4416 and the Filter or Spectrometer. For later Spectrometers (2113 from serial number 427566, and 2114 from serial number 417339) to which a 7-pin DIN socket was fitted, the plug JP 4736 should be replaced by the plug JP 0703, as shown in Fig.3.10.

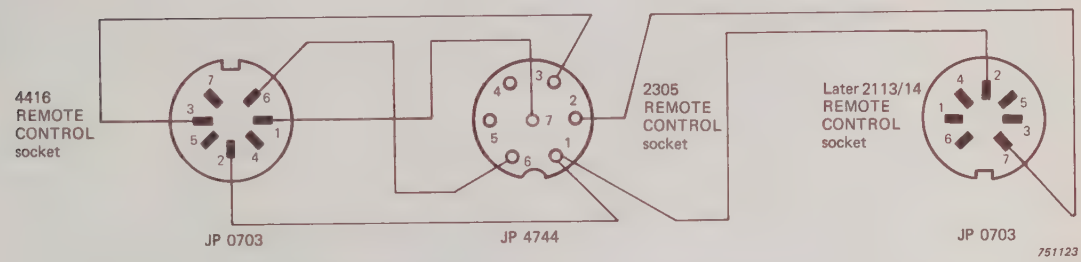


Fig.3.10. Modified cable AQ 0038 for use with later Spectrometers

2. Set up the 4416 and Level Recorder as in items 2 and 3 of section 3.3.1.

3. Set the following controls on the Measuring Amplifier/Spectrometer:

VOLTAGE AND FUSE SELECTOR:	As required
POWER:	"On"
INPUT SECTION ATTENUATOR:	As required
OUTPUT SECTION ATTENUATOR:	"X 1"
INPUT:	"Direct"
FILTERS:	"Ext."

(If a Measuring Amplifier with a DC output is used, then the DC output may be used, and the Level Recorder RECTIFIER RESPONSE should be set to "DC". The LOWER LIMITING FREQUENCY and WRITING SPEED should also be increased to the maximum allowable value; see the 2305 and 2307 Instruction Manuals.)

4. Set the following controls on the Filter/Spectrometer:

VOLTAGE AND FUSE SELECTOR:	As required
POWER:	"On"
SCANNING:	"Remote"
FILTER:	"1/3 Octave"

5. Adjust the position of the paper on the Level Recorder for correct synchronization, and adjust the position of the filter-switching pulses from the Level Recorder as necessary. See the 2305 and 2307 Instruction Manuals.

6. Follow items 5 and 6 of section 3.3.1. If the rotational speed of the turntable is now not exactly 45 r.p.m., the filter switching will gradually drift out of synchronization with the gliding frequency on the record during the measurements.

7. The plotting of the results will take place automatically when the 1 kHz start tone ceases. The pen should start from the 20 Hz line, and should finish above the 20 Hz line on the next chart, ready for a subsequent recording.

In the unlikely event of hum and noise caused by a ground loop, a single lead (no ground) should be used between the Measuring Amplifier (or Spectrometer) output and the Level Recorder.

An example of an automatic selective cross-talk plot made using two successive recordings (one for each channel) is shown in Fig.3.11. Only one channel has been passed through the filter. (It is not necessary for the upper curve to be filtered, in fact, since there should be no signal-to-noise problems. A selective upper curve is shown in Fig.3.17, however.) An example of a plot made by chopping from one channel to the other is shown in Fig.3.12.

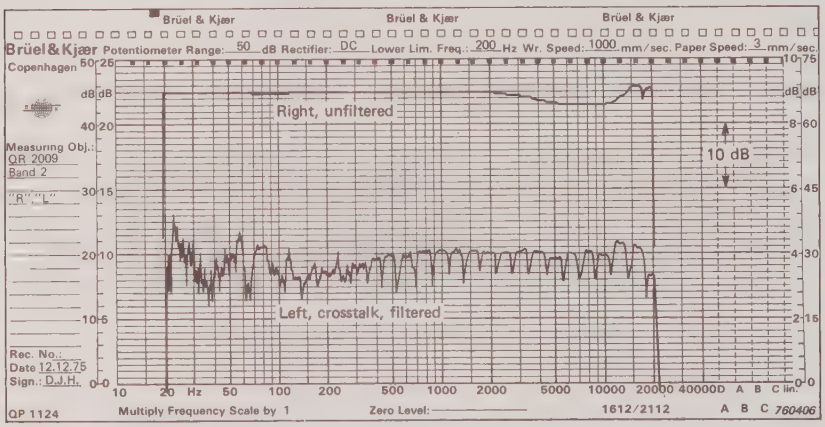


Fig.3.11. Typical cross-talk measurements on a pick-up, plotted successively

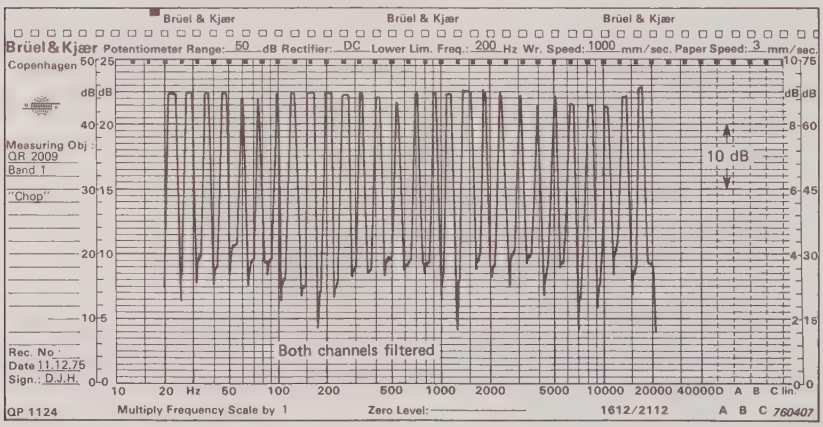


Fig.3.12. Typical cross-talk measurements on a pick-up, plotted simultaneously

3.3.3. Automatic Balance Measurements

To check the balance between the output levels from each channel of the pick-up, bands 3 and 4 or 7 and 8 may be used, recording first one channel and then the other. Different-coloured pens are useful here, as both traces will be close together for a good pick-up, if they are recorded on the same chart.

The instrument set-up is as in Fig.3.4, since no filtering of the signal is necessary, and the procedure is identical to that outlined in section 3.3.1. Two typical examples of traces made in this manner are given in Figs.3.13 and 3.14.

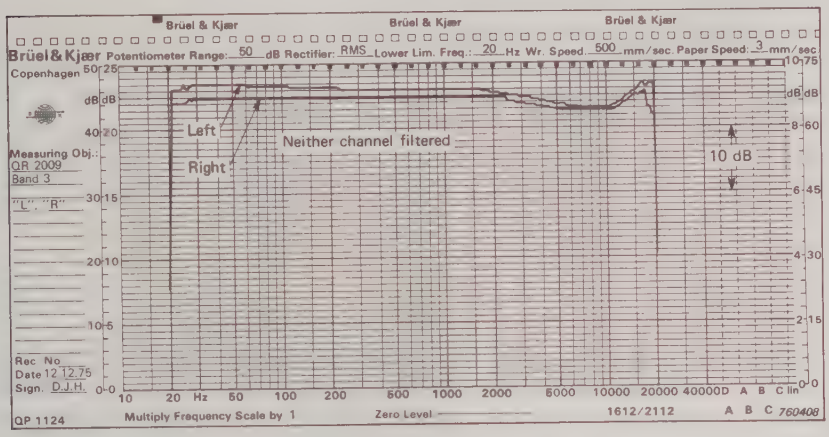


Fig.3.13. Typical balance measurements with lateral motion (L + R)

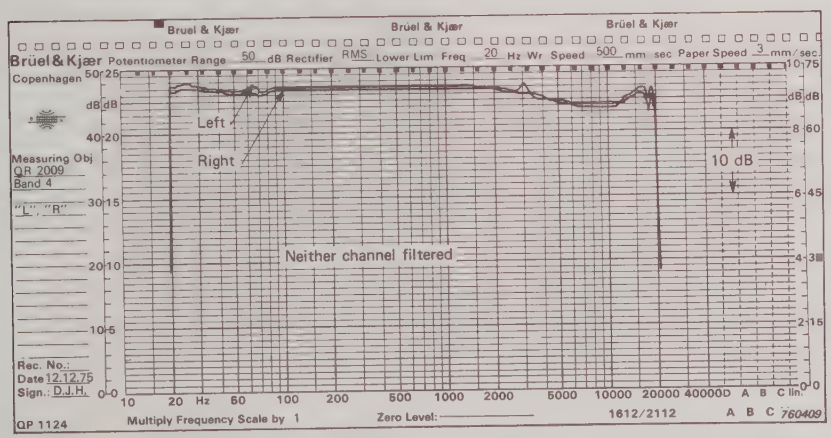


Fig.3.14. Typical balance measurements with vertical motion (L — R)

3.3.4. Automatic Harmonic-Distortion Measurements

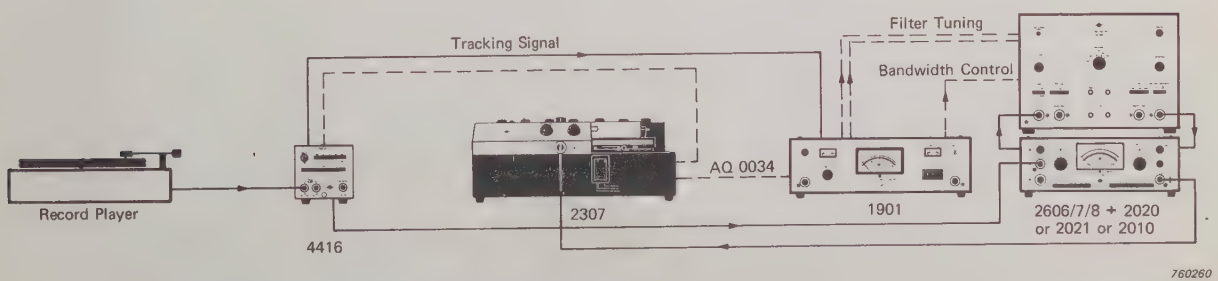


Fig.3.15. Set-up for automatic harmonic-distortion measurements

The 4416 is equipped with a BNC socket on its rear panel (TO 1901) which gives a noise-filtered output signal suitable for feeding to a Tracking Frequency Multiplier Type 1901 for making automatically swept harmonic-distortion measurements. The instrumentation set-up is shown in Fig.3.15.

Any of the bands on the Test Record QR 2009 is suitable for these measurements, and the required channel should be selected on the 4416. With the set-up shown, the 1901 receives a tracking signal from the 4416. The 1901 then controls the Filter tuning (according to which harmonic has been selected) and synchronizes the Level Recorder to the tuned frequency. (Only the Level Recorder Type 2307 may be used for this purpose, as it is controlled via its X-INPUT socket.) The 1901 can also control the bandwidth of the filter if desired. The 2606/07/08 + 2020 combination may be replaced by the 2010 or 2021 (see the 1901 specifications for details of frequency ranges which may be covered by these instruments).

The instructions for setting up the instrumentation, calibration, and operation are covered in detail in the 1901 Instruction Manual for each of the three analyzing methods mentioned above, and the method of synchronizing the 2307 with the tuned filter frequency is explained in the 2307 Instruction Manual. One or two small points should be watched, however. The LIN/LOG selector on the rear panel of the 1901 should be set to "Log.". If a 2010 is used, the frequency tuning pointer should be on the active part of the scale, or no readings will result. (The filter section is tuned externally, so the actual position of the pointer is of no consequence.) Ensure that the filter-tuning cable for connecting the variable oscillator frequency sections is connected to the 2010 EXTERNAL VARIABLE FREQUENCY socket on its rear panel, and NOT the VARIABLE FREQUENCY socket. The maximum allowable 2307 PAPER SPEED setting is "3 cm/s" when using the "X-Rec." position, to ensure stability.

The whole system is started automatically by the cessation of the 1 kHz start tone on the record, and will track any desired harmonic of the signal on the test record within the frequency range of the instruments used. At the end of the recording the Level Recorder paper will stop ready for the next recording.

A typical recording of the second and third harmonics of a good quality pick-up cartridge is shown in Fig.3.16.

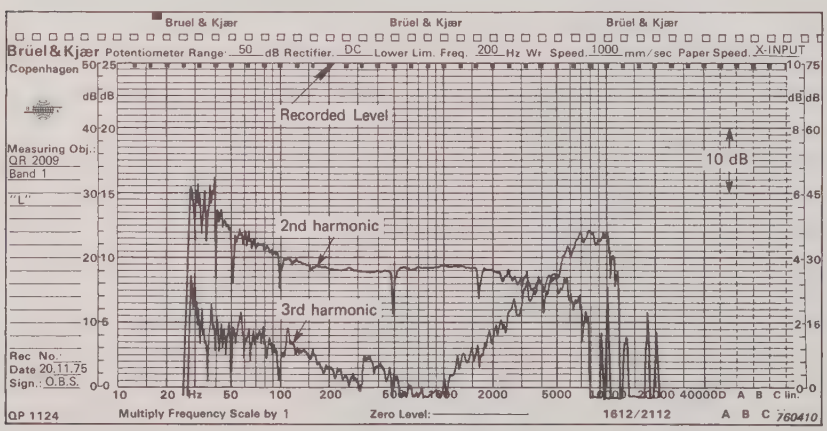


Fig.3.16. Typical harmonic-distortion measurements

Comparison of results using Test Record QR 2009 and QR 2010 should be made with caution because of their different rotational speeds. See Chapter 4.

3.4. USE OF B & K TEST RECORD QR 2010

The rotational speed for this test record is 33 1/3 r.p.m., and the turntable speed should thus be adjusted accordingly. There is a larger number of test facilities incorporated into this test record, and these will be outlined in the following sections. There are lock grooves between some of the bands, so the record cannot be played right through in one go. In principle, however, the operational procedure is similar to that for the test record QR 2009, so detailed instructions will not be given here.

3.4.1. Automatic Frequency-Response and Cross-Talk Measurements (Bands 1 and 2 and 13 and 14)

The test set-up and procedure are identical to those given in sections 3.3.1 and 3.3.2, except that the Level Recorder PAPER SPEED should be increased to "10 mm/s" to allow for the increased frequency-sweep rate on the test record. Bands 1 and 2 may be played consecutively from the lead-in groove for band 1. Non-selective or selective recordings may be made as before. Bands 13 and 14 are identical to bands 1 and 2 (but only up to 20 kHz) to enable measurements to be made at the record's minor diameter. A typical example with selective recording is given in Fig.3.17.

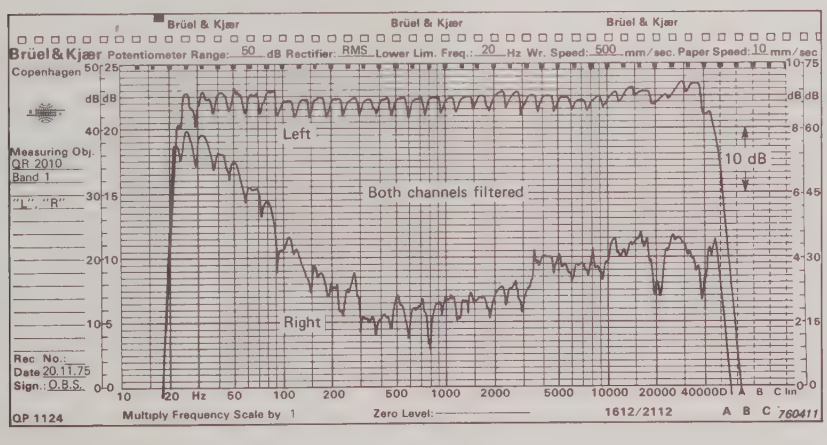


Fig.3.17. Typical frequency-response and cross-talk measurements

3.4.2. Checking Tracking Characteristics at 1 kHz (Bands 3 to 7)

These bands may be played consecutively by placing the stylus on the lead-in groove for band 3. These five bands are designed to enable measurements to be made of the tracking ability of a pick-up at high recording levels. The read-out is best obtained on an oscilloscope screen using the set-up shown in Fig.3.18, although the 4416 is not essential for this application. With correct tracking of the stylus, a sinusoidal waveform of frequency 1 kHz should be seen on the oscilloscope. Any distortion due to mistracking will show up as ripple or fuzziness of the waveform. In severe cases, the waveform may break up completely. The level at which the pick-up can track correctly can now be ascertained.

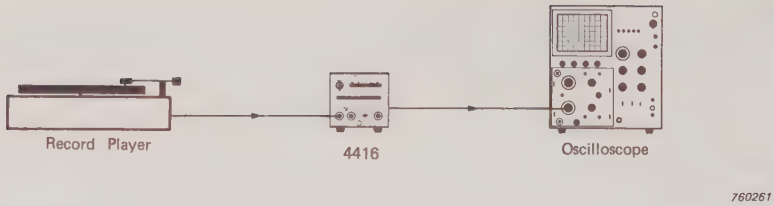


Fig.3.18. Set-up for determination of tracking ability

3.4.3. Wow and Flutter Measurements (Band 8)

Small speed variations of the turntable are termed wow and flutter. Variations below 10 Hz are called wow, and above 10 Hz they are called flutter. This variation is measured as the frequency modulation of a 3,15 kHz signal using the instrumentation set-up shown in Fig.3.19, although the 4416 is not essential for this application. The wow and flutter meter is not yet available from B & K.

Fig.3.19. Set-up for measurement of wow and flutter

3.4.4. Polarity Check (Band 9)

Five signals of short duration at a frequency of 1 kHz are provided. The first (a) is recorded on the left channel only, giving level reference. The second signal (b) is on the right channel only. The third signal (c) is on both channels with the signals in phase. The fourth signal (d) is on both channels with the phase of the right channel shifted 180°. The fifth signal (e) is with both channels is phase again. If the polarity of the connections is correct, the reading of the meter should be zero only for (d), when the 4416 is set to "L + R", using the instrumentation set-up of Fig.3.20. If the polarity of the connections is wrong, signals (c) and (e) will give zero. In this case, the connections should be reversed.

Fig.3.20. Set-up for polarity check

3.4.5. Cross-Talk Measurements of a Quadraphonic Pick-up (Band 10)

The recording consists of four bursts of a 30 kHz frequency tone, two on each channel at two different recording levels (see the specifications), thus enabling cross-talk measurements to be made. The cross-talk of the record is less than — 20 dB. Because of the likelyhood of pick-up distortion, the selective measuring system shown in Fig.3.21 is rec-

ommended, and the filter set must be tuned to a pass band which includes 30 kHz. Play the record using first the "Left" CHANNEL SELECTOR of the 4416, and then the "Right", and note the filtered readings on the meter.

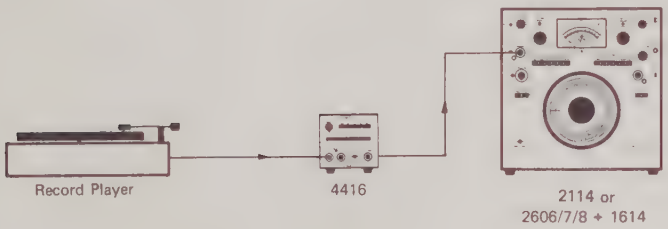


Fig.3.21. Set-up for measurement of cross-talk

3.4.6. Rumble Measurements (Band 11)

This band on the record contains a 315 Hz reference tone, which is unaffected by rumble filter A or B (see Chapter 1, Fig.3), followed by a silent groove. By selecting the required RUMBLE FILTER on the 4416, the rumble may be observed on the meter with reference to the level of the 315 Hz tone. The instrumentation set-up is as shown in Fig.3.20.

3.4.7. Cross-Talk Measurements using an AC Voltmeter (Band 12)

This band is to enable cross-talk measurements to be made with an ordinary AC voltmeter. The cross-talk of this band is less than —30 dB, i. e. the separation between channels is greater than 30 dB. The recommended set-up is shown in Fig.3.20, and the procedure is as follows:

1. Select the "Left" channel on the 4416.

2. Play the first signal (1 kHz recorded on the left channel for reference) and note the level indicated on the voltmeter.

3. Play the second signal (1 kHz signal recorded 20 dB higher on the right channel) and note the level. If the meter deflection decreases from item 2, then the separation at 1 kHz is greater than 20 dB. If the deflection increases, then the separation at 1 kHz is less than 20 dB. The decrease (or increase) in meter reading should be added to (or subtracted from) 20 dB to obtain the channel separation at 1 kHz.

4. Play the third signal (a frequency sweep from 400 Hz to 10 kHz recorded on the right channel). The maximum and minimum cross-talk (minimum and maximum separation respectively) in this frequency range can be observed from the meter reading, and evaluated as in item 3.

5. Select the "Right" channel on the 4416. During the next three signals, repeat the procedure of items 2 to 4 for measurements on the right channel.

3.4.8. Measurement of Tone-Arm Resonance (Band 15)

Measurement of the resonance frequency of the tone arm within the range 5 Hz to 20 Hz is possible using this band, which contains a very slow frequency sweep between those two values. As with bands 1, 2, 13 and 14, a 1 kHz start-synchronization signal is provided. The instruments should be set up as shown in Fig.3.4. The procedure is similar to that described in section 3.3, with the following differences:

a) either channel may be used

b) the Level Recorder should have the following settings:

LOWER LIMITING FREQUENCY:	"2 Hz"
WRITING SPEED:	"16 mm/s"
PAPER SPEED:	"1 mm/s"

c) the sweep should start at 5 Hz, and end at 20 Hz.

A typical trace of a tone-arm measurement is shown in Fig.3.22, indicating a resonance at 9 Hz.

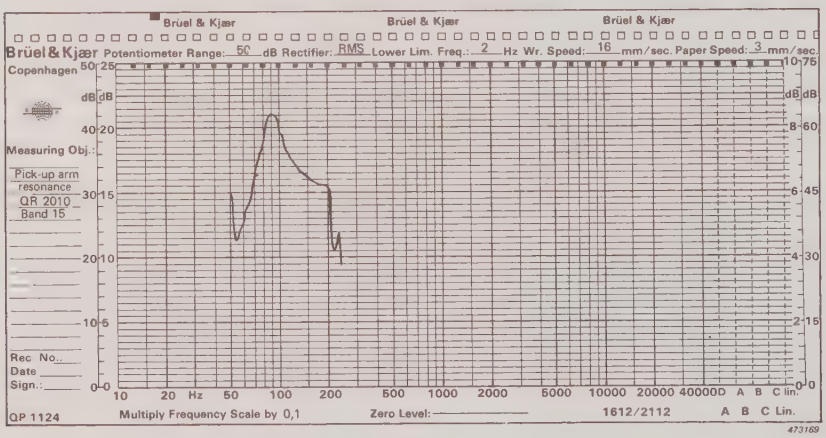


Fig.3.22. Typical recording of tone-arm resonance

3.5. USE OF B & K TEST RECORD QR 2011

For completeness, a brief discussion of the use of the test record QR 2011 is included here, even though it was not specifically designed to be used with the 4416. The main difference between this record and the other two is that this is designed to test complete audio reproduction systems, preferably when they are installed in the actual listening room, whereas the others are only for testing pick-ups, turntables, and perhaps preamplifiers. Furthermore, the only instrument necessary for measurement is a Sound Level Meter; a B & K Type 2203 or 2206 is eminently suitable for this purpose.

The record programme consists of third-octave and wideband pink-weighted noise, enabling measurements to be made on the total system: pick-up, RIAA equalization, preamplifier, power amplifier and loudspeakers. (The RIAA characteristics of the record may be checked using the 4416.) The system measurements are only valid in the actual room where they were made.

Although this method of testing does not give all the information necessary for a com-

plete test (it does not check transient performance, phase characteristics, noise and distortion, for example), it is simple, and the results agree extremely well with the results of listening tests conducted with a variety of loudspeakers in several listening rooms. (See B & K Application Notes 13—101 and 14—114.)

3.5.1. Manual Recording of Frequency Response (Side B, Bands 1 and 2)

1. With the operator in the normal listening position, switch on the Sound Level Meter, and measure the background noise in the room, using the "Lin." "Slow" position.

2. Play the 1 kHz calibration band of the QR 2011 (side B, band 1) with the tone controls in their normal position and set the amplifier volume control of the system under test to give a reading on the 2206 **at least 10 dB higher** than the room's background noise level.

3. Play the measuring signals (side B, band 2). Use the 1 kHz pure tone at the beginning of the track as a further check of the level. (To check just the right or left channel singly, do NOT use side A because of translation losses — those bands are for channel separation measurements — simply adjust the balance controls of the amplifier as required.)

4. At the beginning of each third-octave pink-noise band, its centre frequency is announced. Note the frequency and the sound pressure level for each third-octave band.

5. Plot the points corresponding to sound pressure level for each thrid-octave band on paper QP 2011. A typical example is given in Fig.3.23. The optimum reproduction of most music records is achieved when this curve is similar to that shown in Fig.3.24.

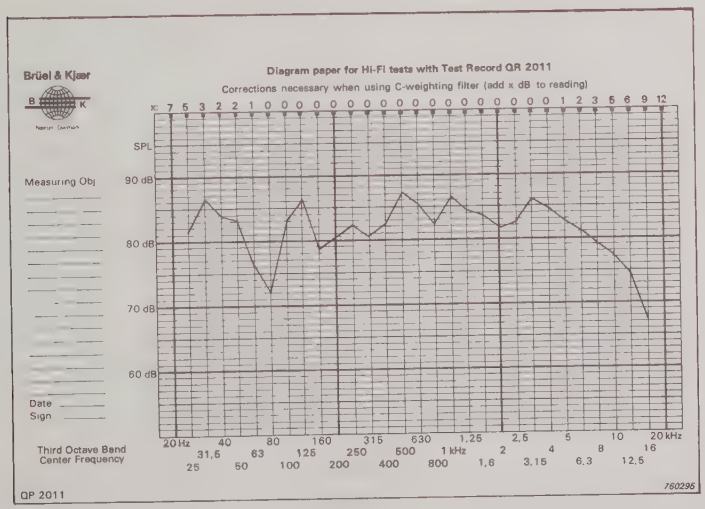

Brüel & Kjær
Diagram paper for Hi-Fi tests with Test Record QR 2011
Corrections necessary when using C-weighting filter (add x dB to reading)
SPL
90 dB
80 dB
70 dB
60 dB
Measuring Obj
Date
Sign
Third Octave Band Center Frequency
20 Hz 25 31,5 40 50 63 80 100 125 160 200 250 315 400 500 630 800 1 kHz 1,25 1,6 2 2,5 3,15 4 5 6,3 8 10 12,5 16 20 kHz
QP 2011
760296

Fig.3.23. Typical frequency response in a listening room

When making measurements as above, it is possible that errors can creep into the measurements. In general, these errors will take form of extraneous noise (from distortion or from other external sources), and will help to fill in the gaps in the frequency-response curve, thus making it look better than it really is. These other sounds become a problem particularly at frequencies below 100 Hz or above 10 kHz, where the output of many reproducing systems decreases. Some typical causes of distortion are discussed below.

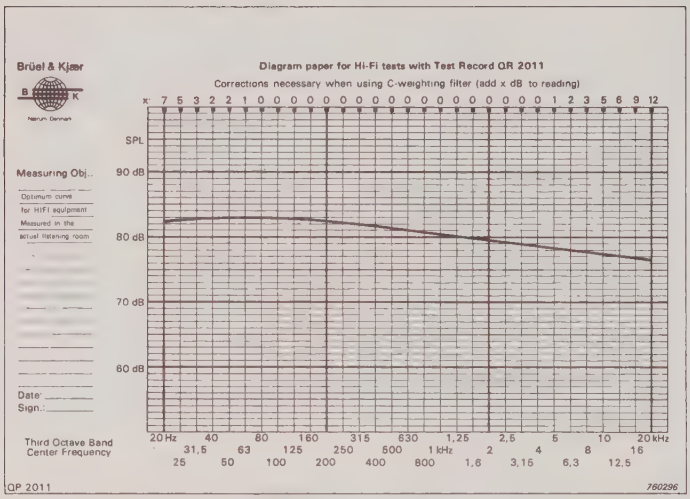

Brüel & Kjær
Diagram paper for Hi-Fi tests with Test Record QR 2011
Corrections necessary when using C-weighting filter (add x dB to reading)
x: 7 5 3 2 2 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 2 3 5 6 9 12
SPL
90 dB
80 dB
70 dB
60 dB
Measuring Obj..
Optimum curve for HIFI equipment Measured in the actual listening room
Date:
Sign.:
20 Hz 40 80 160 315 630 1,25 2,5 5 10 20 kHz
31,5 63 125 250 500 1 kHz 2 4 8 16
25 50 100 200 400 800 1,6 3,15 6,3 12,5
Third Octave Band Center Frequency
QP 2011
760296

Fig.3.24. "Ideal" frequency response in a listening room

If the signal level is very high, it can cause distortion, so that not only the signal but also harmonics, subharmonics, and intermodulation products of the signal are measured. If the level of the distortion products is high, this can give errors, particularly at low frequencies.

The use of a filter, such as the B & K Third-Octave Filter Set Type 1616, which can be fitted directly onto the B & K Sound Level Meter Type 2203, can drastically reduce these effects, and is therefore recommended. The filter should be tuned to the centre frequency of the band being measured, and this will cut out noise from distortion and external sources, thus improving the signal-to-noise ratio of the measurement.

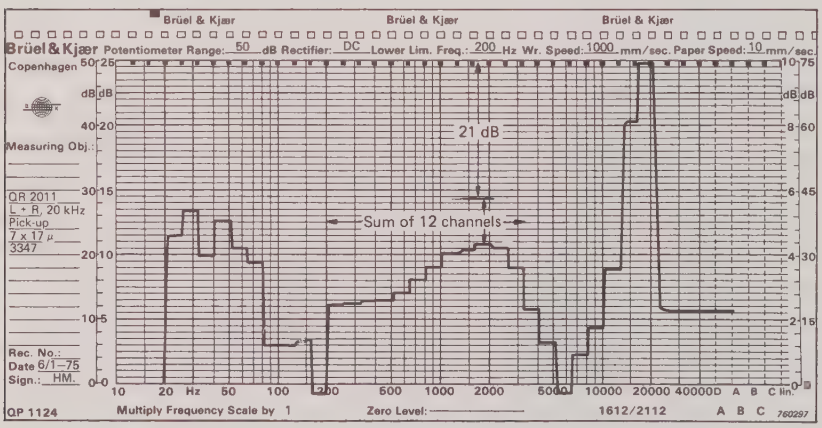


Fig.3.25. Distortion caused by poor trackability

At high frequencies, the velocity of the stylus in the groove is very high. If the trackability of the stylus is not high enough, the stylus is thrown around in the groove, producing distortion which is also measured. Unfortunately, the noise produced will typically be in the range 1 kHz to 4 kHz where the ear is most sensitive. A typical example, showing the noise present when measuring on the 20 kHz band is given in Fig.3.25, indicating a 21 dB signal-to-noise ratio when the adjacent noise bands are summed together as shown in the figure. (A 10 dB signal-to-noise ratio is adequate for selective measurements, but considerably higher values are necessary for the noise to become insignifi-

cant in listening tests.) This can be made worse by translation loss, which could lead to only a 4 dB signal-to-noise ratio (see Fig.3.26) when the adjacent noise bands are summed together as shown in the figure. These signals have already been filtered, and have been measured electrically. The acoustical situation would probably be worse again due to the roll-off of the loudspeakers at high frequencies.

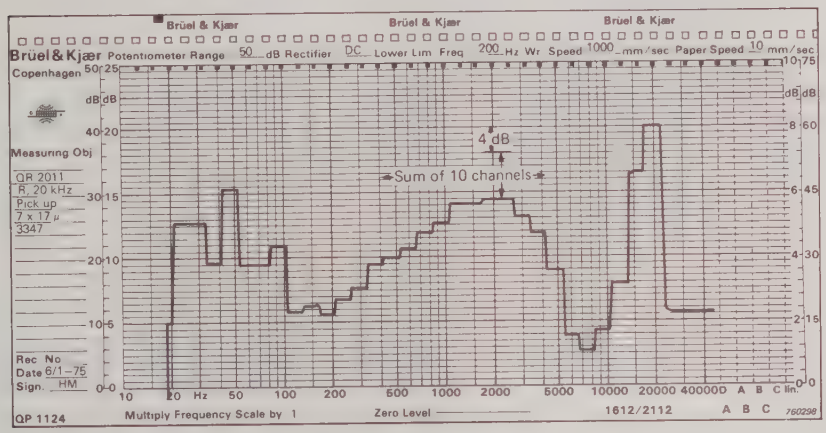

Brüel & Kjær
Brüel & Kjær Potentiometer Range 50 dB Rectifier DC Lower Lim Freq 200 Hz Wr Speed 1000 mm/sec Paper Speed 10 mm/sec
Copenhagen
Measuring Obj
QR 2011
R, 20 kHz
Pick up
7 x 17 µ
3347
Rec No
Date 6/1–75
Sign. HM
4 dB
Sum of 10 channels
10 20 Hz 50 100 200 500 1000 2000 5000 10000 20000 40000 D A B C lin
QP 1124
Multiply Frequency Scale by 1
Zero Level
1612/2112
A B C
760298

Fig.3.26. Distortion caused by poor trackability, aggravated by translation loss

In Fig.3.26, not only did the signal level drop due to translation loss, but the distortion noise also increased since the recording was only made on one channel of the record. A 4 dB signal-to-noise ratio is much too small for meaningful measurements to be made, but fortunately the situation can be improved. Use of the 4416 "L + R" mode considerably reduces this effect, although it does not help in listening tests. Fig.3.27 shows the response of a good quality pick-up using both channels separately. Fig.3.28 shows the response of the same pick-up when the 4416 has been set to "L + R", giving an increase in signal-to-noise ratio from about 17 dB to about 30 dB when measuring on the 16 kHz band when the adjacent noise bands are summed together as shown in the figures.

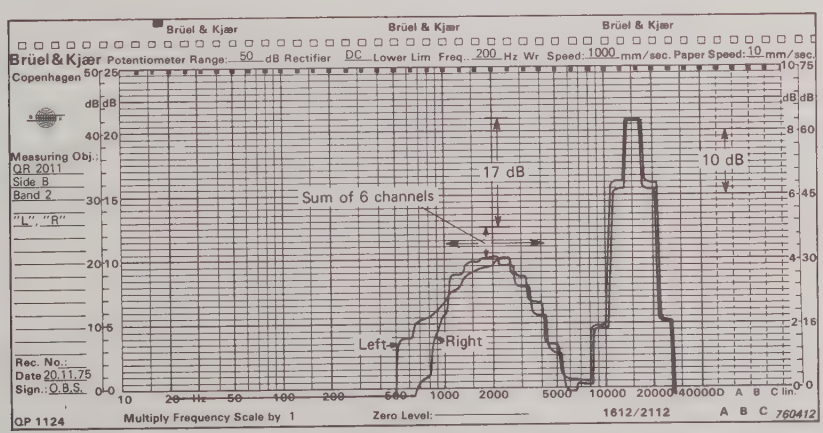


Fig.3.27. Distortion in individual channels

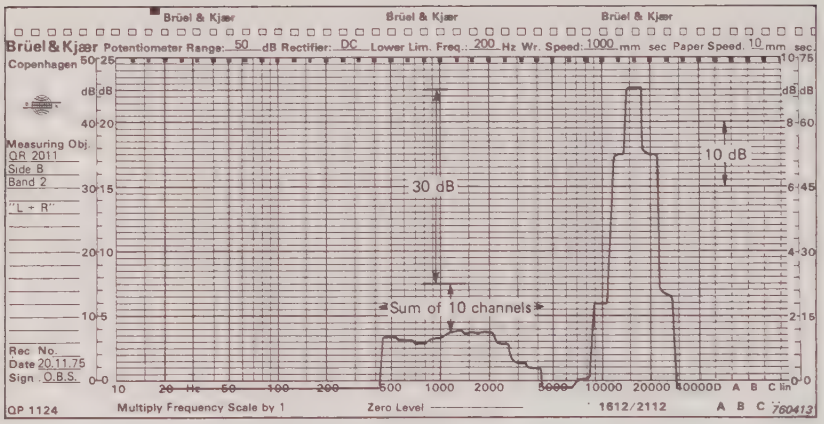


Fig.3.28. Distortion using 4416 "L + R" mode

Another means of improving the signal-to-noise ratio, for both listening and measurements, is to increase the stylus pressure, up to about 3 times its normal value. This prevents the stylus from being thrown around, and increases the signal-to-noise ratio by about 10 dB for normal pick-ups; and then use of the 4416 "L + R" mode improves the situation further for measurements. Fig.3.29 shows the effect of increasing the stylus "pressure" from 1 gm (~ 10 mN) to 2 gm (~ 20 mN) to 3 gm (~ 30 mN) when measuring on the 20 kHz band with a good quality pick-up. With good quality modern pick-ups with a low recommended stylus pressure, increasing it as suggested will not harm the record. In fact, it will probably do less damage than when the stylus was being thrown around in the groove at a lower stylus pressure.

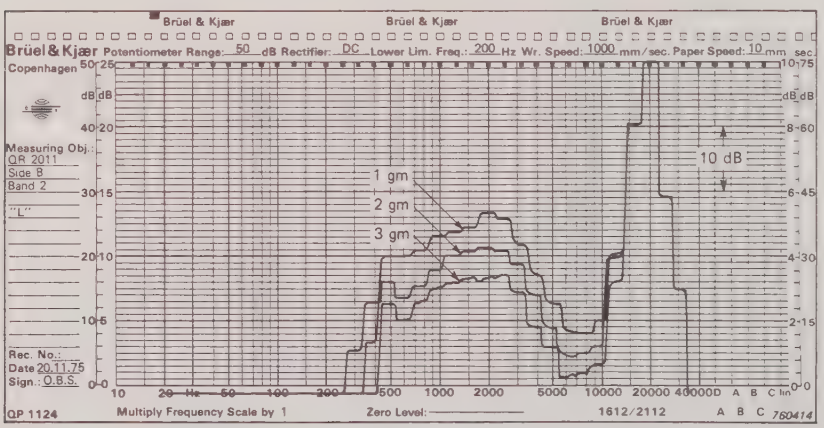


Fig.3.29. Effect of increasing stylus pressure

No corrections should be made to the results of measurements for translation loss, as this will also occur when playing ordinary records. If measurements are made using a C-weighting network (or other weighting), then the measured results plus the corrections indicated on the graph paper QP 2011 (or corrections for other weightings, as necessary) should be plotted.

If comparative tests between different sets of loudspeakers are to be carried out, for example, it is important that loudspeaker and Sound Level Meter positions should be the same for each test. In the worst case, response variations due to changed positions are likely to be within the frequency range 50 Hz to 2000 Hz, and within ± 5 dB, but are typically much less. Some examples of the effect of moving the Sound Level Meter are given in B & K Application Note 14—114.

Variation of the loudspeaker position can be used for improvement of the lower-frequency response, whilst high-frequency response is only slightly dependent on the room. At high frequencies, however, the phase response seems to be more important. See B & K Application Note 14—115.

In general, one measurement in the normal listening position will in most cases be sufficient.

3.5.2. Using the Sound Level Meter Type 2206 as a Voltmeter

Every part of the system under test can be checked electrically using the Sound Level Meter Type 2206, with the Input Adaptor JJ 0037, as a voltmeter. These electrical measurements, with the QR 2011 used as a source, can give important information about the stylus and pick-up, the equalization curve, the preamplifier, the tone controls, the power amplifier and the cross-over networks of the loudspeakers.

3.5.3. Cross-Talk Measurements (Side A, Bands 1 — 4)

For cross-talk measurements, side A of the record is used. The voltages at various points in the system can be measured as in section 3.5.2 for each channel, noting values at each frequency. The voltage ratio at each frequency can then be converted into dB. The acoustic crosstalk between channels is not normally measured.

3.5.4. Automatic Frequency-Response Measurements (Side B, Band 3)

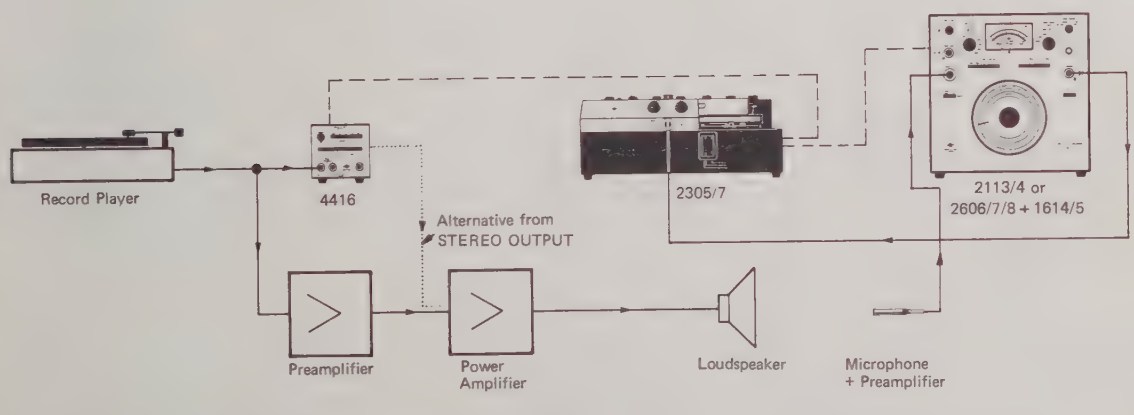


Fig.3.30. Set-up for automatic frequency-response measurements

This band on the record is similar to all the previous ones, but it has no voice comments announcing the centre frequency of the third-octave bands, and it is recorded at a higher sweep rate. A 1 kHz tone is available at the beginning to start the Level Recorder via the

4416, using the set-up shown in Fig.3.30. The procedure is the same as that described in section 3.3.1 except that the signal now comes from the Sound Level Meter (and Filter), or Microphone and Spectrometer, and the Level Recorder PAPER SPEED must be "1 mm/s".

An alternative set-up to Fig.3.30 would be to take a signal from the STEREO OUTPUT of the 4416 (using its preamplifier) and feed this directly to the power amplifier of the system under test. This is shown dotted in Fig.3.30.

3.5.5. Phase Check of the Entire System (Side B, Band 4)

When the loudspeakers of the system are correctly phased, their diaphragms move forward at the same time and backward at the same time for the same signal. This is heard as a sound between the loudspeakers (when sitting in the normal listening position) when they are in phase, and as noise from all sides when they are out of phase. The first 30 s of this band is with the correct phase, and the second 30 s is with the signals in each channel out of phase. If the loudspeakers are out of phase, the leads to one of them should be reversed.

3.5.6. Phase Check of Individual Parts of the System (Side B, Band 5)

The band-pass pink noise from 20 Hz to 1 kHz can be used for checking the phase of the bass system, the 1 kHz to 4 kHz for the mid-range loudspeakers, and the 4 kHz to 20 kHz for the treble system. All of these signals have the correct phase.

3.5.7. Tracing Resonant Parts (Side B, Band 6)

Many items may be excited by the sound (and vibration) from the loudspeakers, and be caused to vibrate, creating unwanted sounds. A few examples are: books and ornaments on the same shelf as a loudspeaker, loose glass in windows, ash-trays on the table, the loose front baffle of a loudspeaker cabinet, etc.. The slow sine sweep of this band should facilitate the locating of such objects.

3.5.8. Subjective Assessment of Frequency Response (Side B, Band 7)

With some practice, the worst defects of a system (and its environment) may be detected just by listening. The best adjustment of the system (using the tone controls) is obtained when all the tonal ranges are considered to be equally powerful. This band can also be used for making selective measurements, for example, with a Sound Level Meter and Filter, with or without a Level Recorder, and no synchronization is necessary (except between Filter and Level Recorder).

3.5.9. Improving the Sound

Having finished making measurements with the Test Records, particularly the QR 2011, there will probably be some things about which the user is dissatisfied, as far as his system and listening room are concerned. Correct tonal balance can often be obtained by adjusting the tone controls as necessary. A few other pointers on improving the sound may be found in B & K Application Note 15—067: Relevant Loudspeaker Tests in Studios, in Hi-Fi Dealers' Demo. Rooms, in the Home, etc. — using Third-Octave Pink-Weighted Random Noise. This is available free of charge direct from Brüel & Kjær.

3.6 TAPE-RECORDER TESTING

3.6.1. General

The following sections apply not only to tape recorders but also to other similar devices, such as the sound-reproducing part of a motion-picture system, dictating machines, etc..

Care of the equipment

As with record-player testing, it is important that the tapes and the tape recorder are looked after carefully. Fingers should be kept off the playing surfaces of the tape as much as possible (special care should be taken on loading the tape when using reel-to-reel types, for example), and the record, playback and erase heads of the recorder should be kept clean in accordance with the manufacturer's instructions. If test recordings are to be made via the microphone, this too must be used carefully, and as recommended by the manufacturer.

Tape-Deck Requirements

If a tape recorder is to be used as a standard reference machine (to record tapes to test the playback system of another recorder, or to play back the tape recorded on another machine to test its recording characteristics, for example), then a good professional recorder should be selected. The requirements of little wow and flutter, and an almost vibration-free environment, are as important here as with record-player testing (see section 3.2.1).

Extension of Frequency Range

Since test frequency on playback is proportional to tape speed, it is possible to extend the frequency range of tests by reducing or increasing tape speed. Since pre-emphasis and de-emphasis are not normally used for tape-recorder testing, there are no problems with altering the equalization networks. (Both the "IEC" and "Lin." push buttons should be in their outer position to keep noise to a minimum, even though these de-emphasis networks themselves have no effect on the signal.)

3.6.2. Recording of Test Tapes

The testing of tape recorders, etc., is similar in principle to record-player testing, in that the same parameters have to be measured in the main. One major difference is that test tapes have to be recorded, and to get meaningful results, these tapes should be carefully prepared, and only good-quality tapes should be used.

If tapes are to be recorded or played back on a reference machine, then quite clearly recording and playback are entirely separate procedures. B & K signal generators may be used for recording, or any other source, and recordings may either be made directly or via a loudspeaker/artificial voice and a microphone. Probably the cheapest way of recording a test tape is from the B & K Test Records, since no generators, etc., are necessary then. However, a high-quality record player is necessary, and things like channel separation and signal-to-noise ratio should be watched carefully. Further complications are added due to translation and playback losses from the record, so this method is not really recommended, since allowances need to be made for all these factors.

In many instances, the overall recording and playback characteristics of the system under test will be investigated, and it is then usually possible to record and play back the signals "simultaneously" (allowing for the delay between heads), thus saving a great deal of time. (In some machines, such as cassette recorders, it is not possible to record and play back simultaneously, however.) This technique also simplifies the synchronization of filters on playback, and is dealt with in more detail in section 3.6.4.

The type of signal to be recorded depends on what parameter is being investigated; in general, the required signal will be similar to that recorded on the Test Records for that particular function, and these signals are all listed at the end of Chapter 1. The left and right tracks just become the two channels of the (stereo) tape recorder.

Two typical recording set-ups are given in Figs.3.31 and 3.32, the first making a direct recording of an electrical signal, the other a recording of sound via a microphone. The Level Recorder is used to give a steady sweep from the generator. A feedback system keeps the acoustical signal from the Artificial Voice at a constant sound pressure level from 50 Hz up to about 10 kHz, in the case of recording via the microphone. The signal from the 1023 goes to the 4416 GENERATOR input, and onto both channels of the tape recorder if all pins are connected as in Fig.3.31.

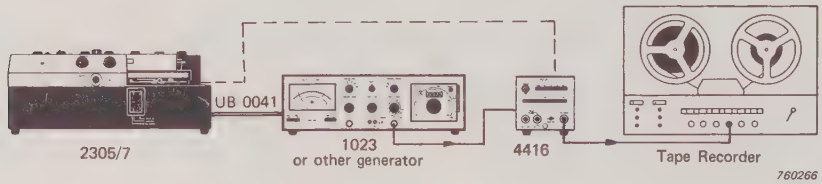


Fig.3.31. Set-up for directly recording a frequency sweep on a test tape

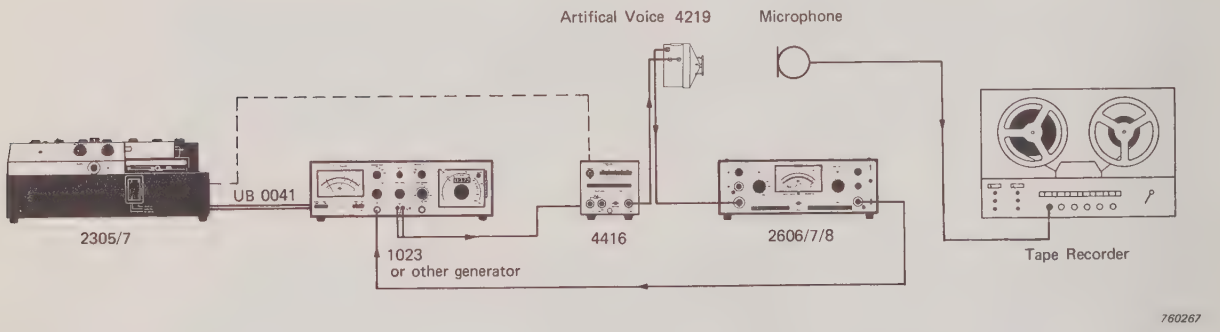


Fig.3.32. Set-up for recording a frequency sweep on a test tape via a microphone

The procedure for recording a frequency sweep on a test tape is as follows:

1. Set up the instrumentation as shown in Fig.3.31 or 3.32, as required.

2. Set the controls of the generator to give the type of signal required (see its Instruction Manual for details).

3. Set the following controls on the 4416:

   FUSE AND VOLTAGE SELECTOR: As required
   POWER: "On"

EQUALIZING SELECTOR:	All buttons "Out"
SYNCHRO START:	"Man."

The position of the other controls is not important.

4. Set the Level Recorder to give the required sweep speed, as follows:

FUSE AND VOLTAGE SELECTOR:	As required
POWER:	"On"
PAPER DRIVE:	"Continuous F" (2307)
	"Start, Forward" (2305)
MOTOR:	"On" (2305)
PAPER SPEED:	"0,3 — 3 mm/s" (suggested)

The position of the other controls is not important. With the flexible drive shaft UB 0041 connected to DRIVE SHAFT I of the Level Recorder, the generator will provide a suitable sweep rate for later analysis. (Too fast a sweep rate should be avoided in case the filter used for analysis cannot respond quickly enough to give accurate results. See the Instruction Manual for the Filter or Spectrometer to be used.)

5. Select the required tape speed and set the tape recorder to its "Record" mode.

6. Adjust the output level of the generator and/or the recording level of the tape recorder to give a suitably sized input signal. Too large a signal will cause distortion and too small a signal can give signal-to-noise problems.

7. Set the frequency of the signal generator output to the frequency of the start of the sweep, and then cut off the generator output using its noiseless switch.

8. Start the tape recorder, and wait a few seconds for the tape speed to settle, then depress the generator 1 kHz tone push button and release the generator cut-off switch. This will produce a 1 kHz tone on the tape for later synchronization of the start of the Level Recorder. It is important that this signal is free from "flaws" or wow which might be able to start the Level Recorder too early on playback. High-fidelity tape and a short start signal help to reduce this risk.

9. With the generator 1 kHz tone push button depressed, depress the "Man." button of the 4416. After a second or two of the 1 kHz tone has been recorded, release both the generator 1 kHz tone push button and the 4416 "Man." button simultaneously. The Level Recorder will start, and thus start the frequency sweep at the instant the 1 kHz tone stops. B & K generators have an controlled output level which is maintained constant throughout the sweep.

   It is also possible to start the Level Recorder directly by depressing the SINGLE CHART/CONT. REC. push button on the 2305 or the START push button on the 2307 at the instant the 1 kHz tone is stopped. (In this case it is not necessary to have a remote control cable from the 4416 to the Level Recorder, and its paper-drive controls should be set accordingly.)

10. When the required sweep is recorded, stop the tape recorder, generator and Level Recorder. The tape is now ready for tests, and should be carefully stored until it is to be replayed.

To record consecutive third-octave bands of pink or white noise, the procedure is similar. The generator should be set to give pink or white noise, and the output filtered, switching the filter from the Level Recorder.

3.6.3. Measurements using Test Tapes

Once a test tape has been recorded in the manner outlined in section 3.6.2, playback and analysis procedures are virtually identical to those for testing record players. The main differences (apart from the source of the signal) are that the 4416 TAPE RECORDER input should be used, with all its EQUALIZING SELECTOR push buttons in their outer position, and that some tests, such as tone-arm resonance, are no longer applicable. The electrical signal for measurement may be taken from any convenient point in the machine under test; the 1 kHz tone for synchronously starting the Level Recorder must be at least 100 ms long (a second or two has been suggested in section 3.6.2 for recording) and must have a level of at least 100 mV at the 4416 TAPE RECORDER input. The remainder of the analysis instrumentation will be as already shown in the appropriate figure for record-player testing, and instrument settings will be as described in the appropriate section.

If the complete tape recorder is being tested, including its amplifiers and loudspeakers, then the set-up should be as shown in Fig.3.33. This set-up is suitable for frequency-response measurements, but for cross-talk or distortion measurements, then a filter should be introduced into the instrumentation. The Level Recorder should then drive the filter at the appropriate sweep rate.

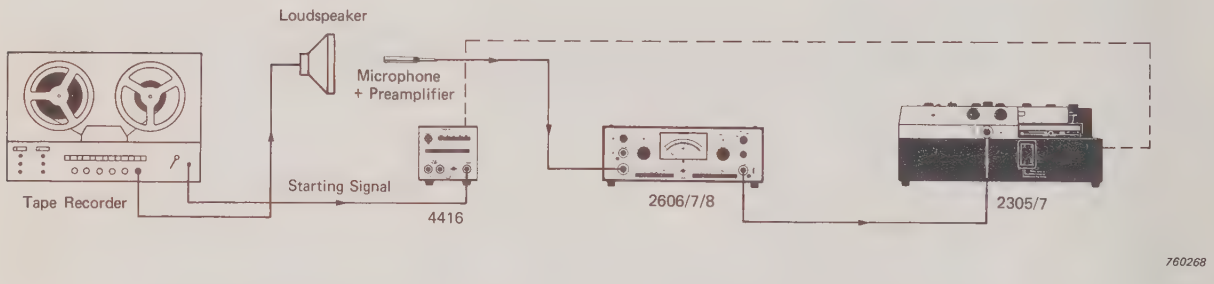


Fig.3.33. Set-up for measurements of a complete tape-recorder response

3.6.4. Simultaneous Recording and Playback

The basic principle of simultaneous recording and playback is the same as when the operations are performed separately. However, there will be some delay between the time when the signal is recorded and the time when the signal is replayed due to the distance between the heads. This time delay is quite clearly dependent on the tape speed as well as the distance. The main thing to remember is that frequency sweeps must be slow enough to ensure that the tuned filter frequency does not go out of adjustment with the signal on the tape, i. e. the filter must not get switched too soon, before the correct part of the tape reaches the replay head. If the Level Recorder paper and the filter switching are synchronized to the replayed signal, and not the recorded signal, this problem is minimized. It is also important to ensure that the sweep speed is sufficiently slow for the filter to be able to respond correctly to the signal. A guide to sweep speeds is given in B & K Application Note 15—098: Swept Measurements of Harmonic, Difference Frequency, and Intermodulation Distortion, available free of charge from Brüel & Kjær. A 1 kHz tone for a synchronous start signal is not necessary, but if the recorded tape is to be used for further tests, then it may be useful to record such a tone.

A typical measuring set-up, including a band-pass filter, is shown in Fig.3.34. The signal to be recorded is fed from the 1023 to the 4416 GENERATOR input, out through it TAPE RECORDER socket (pins 1, 2, 4) and into the tape recorder. The playback signal is

fed back through the 4416 TAPE RECORDER socket (pins 2, 3, 5), out through its AC OUTPUT socket to the Measuring Amplifier/Filter, and then to the Level Recorder, which also drives the 1023 and tunes the Filter. A guide to the use of each individual instrument will be found in its own Instruction Manual.

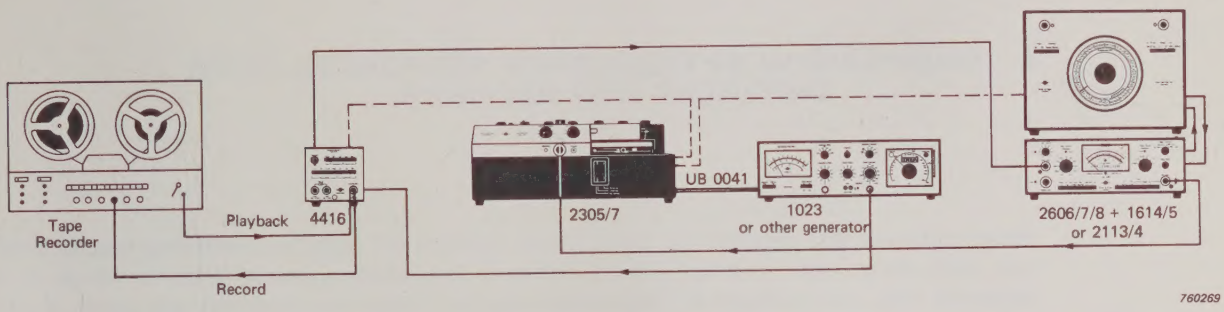


Fig.3.34. Set-up for simultaneous recording and playback of a test tape

3.6.5. Distortion Measurements

Harmonic-distortion measurements are similar in principle to those for record players, as described in section 3.3.4. For making difference-frequency- and intermodulation-distortion measurements, however, a special tape has to be prepared with two signals. The synchronization has to be extremely accurate, so a Tracking Frequency Multiplier Type 1901 has to be used, and a Distortion Measurement Control Unit Type 1902 has to be added to the measurement system. The whole recording and playback procedure is given in B & K Application Note 15—098 (available free of charge from Brüel & Kjær). This note also describes the need for, and the principle of, this type of measurement, and gives some typical measurement results. For clarity, since the interconnection of the 1901, 1902 and 2010 (the 2010 has to be used with the 1902) is not shown in the Application Note, Fig.3.35 shows the rear panels of these three instruments with the connections which have to be made between them for the analysis.

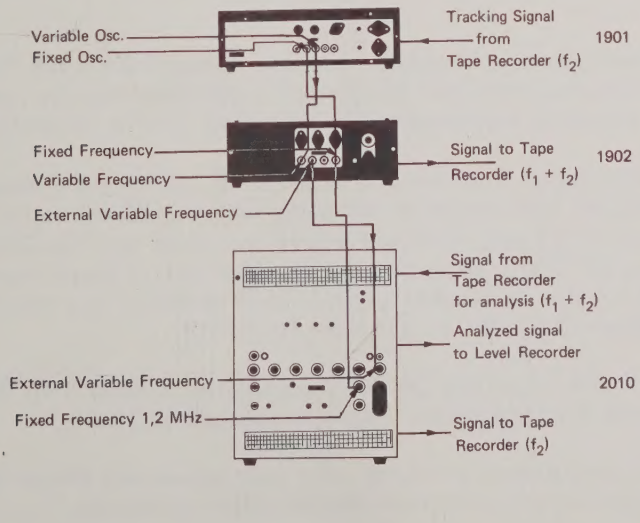


Fig.3.35. Interconnection of 1901, 1902 and 2010 (rear panels shown)

4. COMPARISON OF FREQUENCY RESPONSES FROM DIFFERENT TEST RECORDS

When different test records are used, there is often difficulty in comparing results from one with those from another due to different frequency-response characteristics. It is essential that comparisons of frequency-response curves be made on the basis of the same level and wavelength, where the wavelengths are comparable to the dimensions of the stylus. Wavelength depends on both the frequency and the groove velocity.

Some test records have a rather low recorded level, and thus yield relatively flat frequency responses (due to low translation losses) when compared with results from records with higher recorded levels. However, even the records with high recorded levels can give "beautiful" frequency-response curves, especially if they are compensated for translation losses.

The B & K Test Records (QR 2009 and QR 2010) are cut at 2,24 cm/s RMS with an included angle of 45° — 50° in the sweeps, and they are not compensated for translation losses. (Any correction would probably only be valid for one type of stylus and pick-up anyway.)

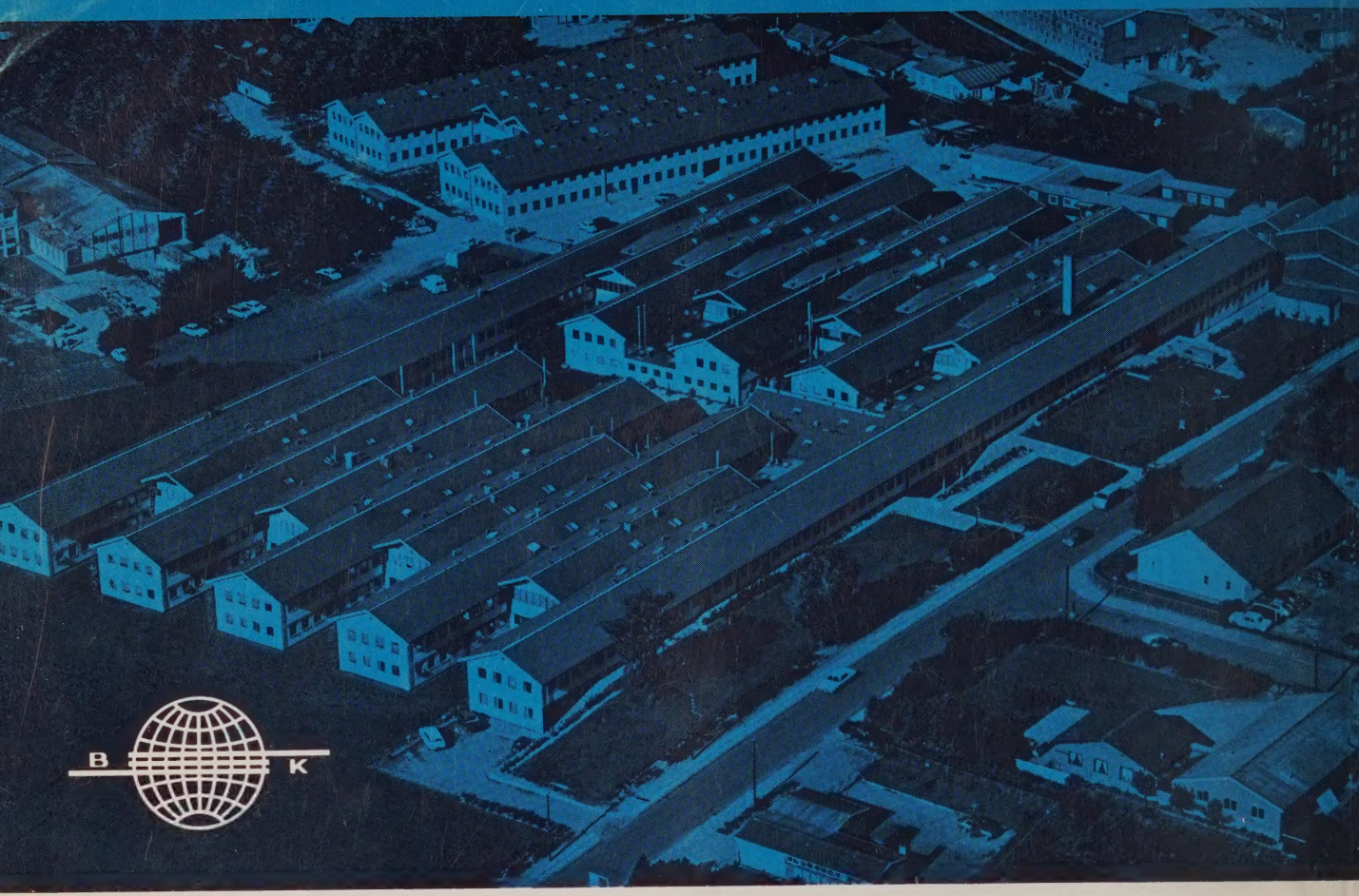
The linearity of the 20 Hz — 45 kHz sweep on QR 2010 is controlled by a special pilot recording where the wavelengths are increased to eliminate translation losses. The so-called "two-speed method" of controlling the frequency response on high-frequency recordings will not work, since the wavelengths are the same and only the frequency is altered — there is a roll-off no matter what speed (frequency) is chosen, due to translation losses.

If a comparison between frequency-response curves from B & K Test Records QR 2009 and QR 2010 is required, then the correct comparison must be made to ensure that approximately the same wavelengths are compared. This is illustrated in the following examples:

1) The 20 kHz signal from band 1 or 2 on QR 2010 has a wavelength λ of approximately 22 μm, and should be compared with the 20 kHz signal from band 5 or 6 on QR 2009 ($\lambda \triangleq 22\ \mu$m). It should not be compared with the 20 kHz signal from band 1 or 2 on QR 2009, since this has a wavelength of approximately 30 μm. These differences are due to the different rotational speeds of the records (45 r. p. m. for the QR 2009 and 33 1/3 r. p. m. for the QR 2010).

2) Bands 13 and 14 on the QR 2010 correspond to band 8 on QR 2009, and link the two records at approximately 15 μm wavelength at 20 kHz.

If the correct comparisons are made, very good agreement should be found between frequency-response curves made from the two different records.



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Standing Wave Apparatus
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Brüel & Kjær DK-2850 NÆRUM, DENMARK · Telephone: + 45 2 80 05 00 · TELEX: 37316 bruka dk

Printed in Denmark B & K Offset